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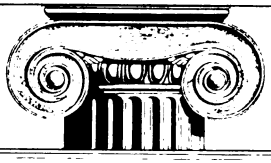

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THEORY AND PRACTICE

OF

THE PHOTOGRAPHIC ART.

THEORY AND PRACTICE

OF

THE PHOTOGRAPHIC ART;

INCLUDING

ITS CHEMISTRY AND OPTICS,

WITH

MINUTE INSTRUCTIONS IN THE PRACTICAL MANIPULATION OF THE VARIOUS PROCESSES, DRAWN FROM THE AUTHOR'S DAILY PRACTICE.

BY W. SPARLING,

ASSISTANT TO MR. FENTON, HONORARY SECRETARY TO THE PHOTOGRAPHIC SOCIETY.

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PHOTOGRAPHIC ART.

Introduction.—Within the last quarter of a century there has not been a discovery more useful, interesting—I may say, more fascinating—than photography. Whether employed as an assistant to the artist, or a means of sending home from far-off scenes of war and death the portrait of a friend, or the spot whereon, perhaps, he died or conquered, what can equal its truthfulness? what can surpass its beauty? By the aid of the sunbeam the physician may now delineate the gradual changes produced by disease, with a faithfulness hitherto unknown; the architect can obtain the most elaborate details of a building in a few seconds. The art has been made subservient to the purposes of the artist, the naturalist, and the mechanic, and even to the antiquary, who,

> "Bending o'er some mossy tomb
> Where valour sleeps,"

may be enabled to preserve a lasting memorial by this art. Viewed in these lights, Photography may justly be considered the most important application of chemical philosophy to develop the powers of nature which modern science has discovered. Premising that the science is at present in its infancy, I shall endeavour to make the present manual as plain, as practical, and as comprehensive as possible, saying nothing, which might require to be afterwards unsaid, nor leaving anything unsaid which may be necessary to elucidate the subject, so far as our present knowledge extends.

Wedgwood's Discovery.—The property possessed by the salts of silver, when decomposed by the action of light, was well known to the earlier chemists; and M. Charles, a well-known French physician, exhibited in his lectures at the Louvre a paper capable of taking silhouette figures by the action of solar light, but he has left no account of his process. Mr. Wedgwood, therefore, was undoubtedly the first person

who recorded his attempts to use the sunbeams for photographic printing. In the year 1802 he published a paper in the Journal of the Royal Institution, which he describes as "an account of a method of copying paintings upon glass, and of making profiles by the agency of light upon nitrate of silver, with observations by H. Davy,"—a gentleman afterwards better known as Sir Humphry Davy. From this paper, the earliest we are acquainted with in which the discovery of these processes present themselves, the following extracts are taken :—

"White paper, or white leather, moistened with a solution of nitrate of silver, undergoes no change when kept in the dark; but on being exposed to the day-light it speedily changes colour, and after passing through different shades of gray and brown, becomes at length nearly black. The alterations of colour take place more speedily in proportion as the light is more intense. In the direct beam of the sun, two or three minutes are sufficient to produce the full effect; in the shade, several hours are required; and light transmitted through different coloured glasses act with different degrees of intensity. Thus it is found that red rays, or the common sunbeams passed through red glass, have very little effect upon it. Yellow and green are more effective, but violet or blue produce the most powerful and decided effect."

"When the shadow of any figure is thrown upon the prepared surface, the part concealed by it remains white, and the other parts speedily become dark. For copying paintings on glass, the solution should be applied on leather; and in this case it is more readily acted on than when paper is used. After the colour has been once fixed on the leather or paper, it cannot be removed by the application of water, or water and soap, and it is in a high degree permanent. The copy of a painting or the profile, immediately after being taken, must be kept in an obscure place; it may, indeed, be examined in the shade, but in this case the exposure should be only for a few minutes; by the light of candles or lamps, as commonly employed, it is not sensibly affected. No attempts that have been made to prevent the uncoloured parts of the copy or profile from being acted upon by light, have as yet been successful. They have been covered by a thin coating of fine varnish, but this has not destroyed their susceptibility of becoming coloured; and even after repeated washings, sufficient of the active part of the saline matter will adhere to the white parts of the leather or paper to cause them to become dark when exposed to the rays of the sun. Besides the applications of this method of copying that have just been mentioned, there are many others; and it will be useful for making delineations of all such objects as are possessed of a texture partly opaque and partly transparent. The woody fibres of leaves, and the wings of insects, may be pretty accurately represented by means of it; and in this case it is only necessary to cause the direct solar light to pass through them, and to receive the shadows upon leather.

"The images formed by means of a camera obscura have been found to be too faint to produce, in any moderate time, an effect upon the nitrate of silver. To copy these images was the first object of Mr. Wedgwood in his researches on the subject; and for this purpose he first used nitrate of silver, which was mentioned to him by a friend as a substance very sensible to the influence of light; but all his numerous experiments as to their primary end proved unsuccessful. In following these processes, I have found that the images of small objects, produced by means of the solar microscope, may be copied without difficulty on prepared paper. This will probably be a useful application of the method; that it may be employed successfully, however, it is necessary that the paper be placed at but a small distance from the lens."

Here we have the first indication of this great discovery. Subsequently, about the years 1810-11, Seebeck made some interesting discoveries as to the production of colour on chloride of silver by solar radiations, the violet rays rendering it brown, the blue producing a shade of blue, the yellow preserving it white, and the red constantly giving a red shade to that salt.

Berard's Discovery.—In the year 1812, M. Berard brought the result of some valuable researches before a commission composed of MM. Berthollet, Chaptal, and Biot, who state in their report that M. Berard had discovered that the chemical intensity was greatest at the violet end of the spectrum, and that it extended, as Ritter and Wollaston had previously observed, a little beyond that extremity. When he left substances exposed for a certain time to the action of each ray, he observed sensible effects, though with an intensity continually decreasing in the indigo and blue rays. Hence they considered it as extremely probable, that if he had been able to employ agents still more sensible, he would have observed analogous effects. To show clearly the great disproportion which exists in this respect between the energies of different coloured rays, M. Berard concentrated, by means of a lens, all that part of a spectrum which extends from the green to the extreme violet; he also concentrated, by means of another lens, all that portion which extends from the green to the extremity of the red. This last pencil formed a white so brilliant that the eyes were scarcely able to endure it; yet the muriate of silver remained exposed more than two hours to this brilliant point of light without undergoing any sensible alteration. On the other hand, when exposed to the other rays, which were much less bright and less hot, it was blackened in less than six minutes.

After some further remarks on the importance of M. Berard's experiments, they proceed as follows:—"If we consider solar light as composed of three distinct substances, one of which occasions *light*, another *heat*, and the third *chemical combinations*, it will follow that each of these substances is separable by the prism into an infinity of different modifications like light itself; since we find by experiment, that each of these properties is spread, though unequally, over a certain extent of the spectrum; and we must suppose, on that hypothesis, that there exist *three spectrums* one above the other; namely, a calorific, a colorific, and a chemical spectrum. We must likewise admit that each of the substances which compose the three spectrums, and even each molecule of unequal refrangibility which constitutes these substances, is endowed, like the molecules of visible light, with the property of being polarised by reflection, and of escaping from reflection in the same positions as the luminous molecules."

From that time numerous experiments were conducted by several eminent researchers, including the discovery of the more celebrated MM. Niepce and Daguerre.

Daguerre and Niepce's Discovery.—To the inventive genius of these gentlemen we are indebted for the first practical application of this great discovery; but, like most great conceptions of the human mind, this art, as we have seen, advanced by slow steps, and was indicated from time to time by the isolated facts we have briefly alluded to.

The researches of M. Niepce were commenced in 1814, but it was not till 1826 that he was made aware, by the indiscretion of an optician employed by both, that M. Daguerre was pursuing the same course of experiments. A correspondence between the two philosophers was the result, and henceforth their researches were pursued in common; and some years later resulted in the discovery of this branch of the art since known as the Daguerreotype. In 1833, M. Niepce died, having communicated all his dis-

coveries to M. Daguerre, and, in 1839, that gentleman, with a most laudable abnegation of self, communicated his discoveries to the public.

Fox Talbot's Discovery.—About the same time Mr. Fox Talbot, stimulated, no doubt, by the patriotic example of M. Daguerre, published the calotype process, thus giving birth to a new branch of the art.

That gentleman, it appears, had been carrying on his experiments for five years previously, in perfect ignorance of what Daguerre and others were doing, and had aimed at a method by which the sensitiveness of the salts of silver was increased to a marvellous degree. I cannot do better than give an extract from his own communication.

After saying how marvellous it seems that, in a few minutes, a picture is produced, displaying the thousand florets of an Agrostis, with all its capillary branchlets, and so accurately delineated, that not one is without its little bivalve calyx, requiring to be examined through a lens, he proceeds:—

"And, again, to give some more definite idea of the rapidity of the process, I will state that, after various trials, the nearest valuation which I could make of the time necessary for obtaining the picture of an object, so as to have pretty distinct outlines when I employed the full sunshine, was half a second." He was then speaking of the paper used in the solar microscope.

Mr. Fox Talbot also published an account of his first *photogenic* experiments (for this term was first introduced by that gentleman), and I shall again make use of extracts from it, as they will better convey an idea of his discoveries and their importance than any words of mine:—

"In order to make what may be called ordinary photogenic paper," he says, "I select paper of a good firm quality and smooth surface. I do not know that anything answers better than superfine writing-paper. I dip it into a weak solution of common salt, and wipe it dry, by which the salt is uniformly distributed throughout its substance. I then spread a solution of nitrate of silver on one surface only, and dry it at the fire. The solution should not be saturated, but six or eight times diluted with water. When dry, the paper is fit for use.

"I have found, by experiment, that there is a certain proportion between the quantity of salt and that of the solution of silver which answers best, and gives the maximum effect. If the strength of the salt is augmented beyond this point, the effect diminishes, and, in certain cases, becomes exceedingly small.

"This paper, if properly made, is useful for all photogenic purposes. For example, nothing can be more perfect than the images it gives of leaves and flowers, especially with a summer sun,—the light, passing through the leaves, delineates every ramification of their nerves.

"Now, suppose we take a sheet of paper thus prepared, and wash it with a *saturated* solution of salt, and then dry it. We shall find (especially if the paper is kept some weeks before the trial is made) that its sensibility is greatly diminished, and, in some cases, seems quite extinct. But if it is again washed with a liberal quantity of the solution of silver, it becomes again sensible to the light, and even more so than it was at first. In this way, by alternately washing the paper with salt and silver, and drying it between times, I have succeeded in increasing its sensibility to the degree that is requisite for receiving the images of the camera obscura.

"In conducting this operation, it will be found that the results are sometimes more and sometimes less satisfactory, in consequence of small and accidental variations in the

proportions employed. It happens sometimes that the chloride of silver is disposed to darken of itself without any exposure to light; this shows that the attempt to give it sensibility has been carried too far. The object is to *approach*, as near as possible, to this condition, without *reaching* it, so that the substance may be in a state ready to yield to the slightest extraneous force, such as the feeble impact of the violet rays when much attenuated. Having, therefore, prepared a number of sheets of paper with chemical proportions slightly different from one another, let a piece be cut from each, and, having been duly marked or numbered, let them be placed, side by side, in a very weak diffused light for a quarter of an hour. Then, if any one of them, as frequently happens, exhibits a marked advantage over its competitors, I select the paper which bears the corresponding number to be placed in the camera obscura."

CHEMISTRY OF PHOTOGRAPHY.

General Remarks.—The wonderful discoveries announced by M. Daguerre and Niepce, and Mr. Fox Talbot, produced a host of followers, who have brought them to the highest perfection. M. Claudet, one of the earliest, discovered a mode of taking objects by subjecting the plate to vapour of chloride of, iodine. Messrs. Fizeau, Caudin, and Leon Foucault, by the aid of divers preparations of bromine, obtained impressions with great rapidity; and, in 1840, M. Fizeau succeeded in fixing the image by means of chloride of gold.

Having thus introduced the subject in the words of the respective authors, and given a brief history of subsequent discoveries, I shall now, previous to going into the manipulating branches of the science, devote some little space to the chemical agents which we shall use, and recommend the reader to make himself as much acquainted with their nature and photographic properties as possible; for I can assure him that if he does not do so, the time spent on the study of the science will be almost thrown away.

The first of the photographic chemicals which will come under our notice, taking them alphabetically, will be—

Acetic Acid.—The strongest acetic acid, named "Glacial," and sometimes "concentrated acetic acid," from its property of becoming solid at low temperatures, contains only about one-sixtieth of its bulk of water. The crystals melt, at about 50°, into a pungent limpid liquid, with a smell resembling strong vinegar, of which, in fact, it is the base; the distilled vinegar of the shops being acetic acid diluted with from 5 to 7 parts of water. It is often contaminated with a trace of sulphuric acid, which may be detected by the addition of a little chloride of barium, when, if any sulphuric acid be present, we obtain a white precipitate.

Acetic acid is of the greatest use in all the photographic processes which require development, as it governs or checks the action of pyrogallic and gallic acids, and the sulphate of iron on the salts of silver undergoing decomposition; it preserves the whites or parts of the picture not acted on by light; it also keeps the picture clean by preventing any decomposition, except that caused by the light. I may add, that tartaric and formic acids are sometimes used for the same purpose, but I am inclined to give the preference to the acetic acid.

Acetic acid is also the best acid for correcting the alkalinity of the nitrate of silver bath, which will be explained at length as we proceed.

Albumen, or white of egg, is very much used in preparing the surface of paper for positive printing. It is thoroughly beaten up with water and salt, the action of the nitrate of silver partly coagulates the albumen, and in turn is converted into chloride of sodium by an excess of nitrate of silver—a combination extremely favourable to the production of a picture by the action of light. Albumen, containing small quantities of sulphur and phosphorus, gradually discolours the solution of nitrate of silver used for exciting or making sensitive. This discolouration may be easily removed by scraping some pipe-clay into the solution, stirring it up, and allowing it to remain for a day or two, and then filtering carefully. Albumen cannot be used with ammonia nitrate of silver, as the alkaline action of the ammonia would prevent coagulation in the albumen, and cause its separation from the paper.

Alcohol.—Alcohol must not be confounded with "spirits of wine," as the latter contains a considerable quantity of water, which would prove almost fatal to the collodion process, causing a precipitate of the cotton and a separation from the ether: a proof of this may be seen at once in a collodion picture that has been taken with a collodion containing much water in the alcohol. Upon drying it, and viewing it by transmitted light, you will at once perceive that it has a *grain* something similar to *fine muslin*, so that it is of the greatest consequence to obtain the alcohol as free from water as possible. To do so it will be best to mix quick lime, powdered, and alcohol together in equal weights, by distilling both together; the alcohol will come over pure, leaving the water with the lime, for which it has a great affinity.

Ammonia is, or ought to be, only used photographically for the purpose of making ammonia nitrate of silver; for which process see *Silver*. It should be kept in a stoppered bottle, as it rapidly absorbs carbonic acid from the air, which converts it into carbonate of ammonia.

Bichloride of Mercury, or corrosive sublimate, is a highly poisonous salt, very sparingly soluble in water, unless free hydrochloric acid be present. It is used for the purpose of improving glass pictures—of which more anon—and for removing the yellowness sometimes caused in the lights of a print, when the gold colouring bath is used.

Bromine.—This is a deep reddish-brown liquid, fuming strongly at common temperatures, and highly suffocating. It exists in sea-water combined with magnesium, and is closely analogous to chlorine and iodine, having stronger affinities than the latter and weaker than the former; that is to say, bromine would displace iodine, and chlorine would displace bromine. It is sparingly soluble in water, soluble in alcohol, more so in ether.

Bromide of Potassium is a mixture of bromine and caustic potash, heated to redness to drive off the oxygen from the *bromate* of potash, the latter becoming bromide of potassium on the loss of its oxygen. It is used for the formation of bromide of silver (see *Silver*).

Chlorine is a greenish-yellow gas, of a pungent and suffocating odour. As has been remarked, closely analogous to the other two of the group, bromine and iodine, the gas has a density of two and a half times heavier than air. It is found abundantly in nature in combination with sodium, in solution in sea-water and rock-salt; and is very useful in the arts for its bleaching properties. It has such a strong affinity for hydrogen that it absorbs it greedily, thus breaking up the structure of the organic substance, the latter being bleached by destroying its colour. It can be always discovered, either free or in combination, by a solution of nitrate of silver, with which it forms a white precipitate (chloride of silver).

Chloride of Sodium, or common table salt, is very useful to the photographer, as it bears the same relation to the positive printing that iodides and bromides do to the negative. Its sources are inexhaustible, being found in large quantities in the ocean as a solution, in the earth as a solid. It is a combination of chlorine and sodium. It fuses without decomposition at a dull red heat; but if the heat be pushed too far it sublimes, and the melted salt on cooling becomes a hard white concrete mass. It is sparingly soluble in weak alcohol, but nearly insoluble in absolute alcohol; it is soluble in three times its weight of water, and crystallizes in cubes which are anhydrous (without water). As chloride of sodium is often contaminated with chlorides of magnesium and calcium, also sulphate of soda, it is best if you can obtain it pure. You must do so by neutralizing hydrochloric acid (spirits of salt) by carbonate of soda. As has been already noticed, it is a very important salt in photography, being used most extensively in the preparation of positive-paper.

Chloride of Ammonia, or muriate of ammonia, is a soluble salt formed by the combination of chlorine and ammonia. It contains more chlorine than an equal weight of chloride of sodium, and may be used instead of that salt in the preparation of positive printing paper.

Chloride of Silver, formed by a combination of chlorine with a solution of nitrate of silver (see *Silver*).

Chloride of Gold.—Take three parts nitro-muriatic acid, put it into a cup, and drop a piece of pure gold into it one-third its weight; let it evaporate until chlorine vapour is disengaged, then let it crystallize. An impurity sometimes found in the iodide of potassium (which see).

Chloride of Potassium.—When there is much carbonate of potash in the iodide, it may be recognised by the crystals being very small and deliquescent (becoming moist when exposed to the air). The carbonate of potash is strongly alkaline to test-paper, and not very soluble in alcohol; indeed it is a question if it is at all soluble in absolute alcohol, but it is soluble in some degree in the weaker alcohols, to which it communicates an alkaline reaction.

The next impurity which comes under our notice is the sulphate of potash. This salt is decidedly not soluble in absolute alcohol, and the iodide of potassium may be freed from it by being dissolved in very strong alcohol. The presence of the sulphate of potash may be detected thus:—Make a solution of chloride of barium, and add a little to a solution of iodide of potassium; a slight milkiness need not be noticed, but if a decided white precipitate fall down, then you must either reject the iodide of potassium, or dissolve it in the strongest alcohol, when the sulphate being insoluble will remain undissolved.

We have now to consider the chloride of potassium. The presence of this salt is not so easily ascertained as either of the others; indeed it is rather difficult, and to discover an alkaline chloride in the iodide of potassium you must proceed thus:—Make a solution of the iodide suspected, and make a solution of nitrate of silver of the same strength, say twenty grains of each to one ounce of *distilled* water, mix and add to the iodide of silver a little liquor ammonia; if any chloride of silver (or chloride of potassium, which would form a chloride of silver) be present, it will dissolve in the ammonia, and after filtration may be precipitated by the addition of pure nitric acid; the iodide of silver must be well washed previous to the addition of the nitric acid, for as the latter often contains traces of chlorine, the presence of any free nitrate of silver, by combining with the chlorine on neutralizing, would very likely cause an error; it is of great im-

portance that the iodide of potassium should be pure, as otherwise it may cause a great deal of trouble; it would not matter so much if the nature of the impurity were known, as in that case we could take steps to counteract its influence.

Cyanide of Potassium is a *highly poisonous* salt, formed by the combination of cyanogen gas and potassium. It generally contains a large per centage of potash, from which it may be freed by boiling in alcohol, which on cooling deposits it in crystals. It has a strong smell of prussic acid, and is freely soluble in water. It dissolves iodide of silver, and is used for that purpose in clearing away all the unaltered iodide of silver from the negative (a positive if on glass). It also removes the stains of nitrate of silver from the skin or linen. When using it on the fingers, be careful that it does not get into any cuts or sores, as it is almost as poisonous as prussic acid itself.

Ether is a highly volatile, inflammable spirit, obtained by distilling alcohol with sulphuric acid; the latter in its re-action removes one atom of water, and by so doing converts one atom of alcohol into one of ether. There are three kinds of ether sold in the shops—ordinary rectified ether, washed ether, and washed and re-rectified ether. Ether is a most important photographic chemical, being the solvent of "gun cotton," with which it forms collodion; and it is very necessary that it should be pure. It should not have an acid re-action with test-paper; it should not turn an alcoholic solution of iodide of potassium rapidly brown; it should not have a high specific gravity from too much alcohol or water; and it should be free from any smell of essential oils or of acetic ether. Provided ether be free from these defects, it matters very little which ether be used; if the ordinary rectified ether be pure, it will be the most economical. I shall treat this subject more fully when speaking of collodion.

Formic Acid is a fuming liquid with a pungent odour; it reduces the oxides of gold, silver, and mercury to the metallic state, and is itself oxidized into carbonic acid. The alkaline formiates possess the same properties. It is rather difficult to determine the strength of the commercial formic acid, it being always more or less dilute. It may be obtained in its full strength by distilling formiate of soda with sulphuric acid. It inflames the skin in the same manner as the sting of an ant, from which it gets its name, being originally discovered in the red ant (*formica rufa*), but is now prepared on a large scale by distilling *starch* with binoxide of manganese and sulphuric acid.

Gallic Acid.—This is obtained from gall-nuts, of which the best kind come from Turkey, being called "Aleppo galls." The galls are exposed, after being powdered, to the action of the air for a long time—five or six weeks. The mass must be kept moist during the operation by the addition of a little water from time to time. Thus the gallic acid is gradually formed from the *tannic acid* first produced, the gallic acid crystallizes in long, needle-like, silky crystals, having an astringent taste, taking about 100 times their weight of cold water to dissolve them; though, when boiling, three times will be enough. They can be easily purified and separated from the mass by boiling up in water, filtering the mixture while hot, and setting aside to cool; the gallic acid will crystallize on cooling. Gallic acid is but feebly acid, and is a very important agent inreducing the silver in the Talbotype process.

Although not strictly in its alphabetical order, I shall now introduce a substance of great importance, produced by the action of heat on the gallic acid.

Pyrogallic Acid.—At a temperature of about 410° Fah., gallic acid is decomposed, and a white sublimate forms, which condenses in lamellar-crystals. Unlike gallic acid, the new substance is exceedingly soluble in water, and is of the greatest importance in

the development of collodion negatives, from the avidity with which it absorbs oxygen. Although termed an acid, it is perfectly neutral.

Gelatine.—This is an organic substance, obtained by boiling bones, horns, hoofs, calves' feet, or similar animal refuse, into a jelly, which, in the mass, is termed "*size*;" or, when dried and cut into slices, "*glue.*" *Isinglass* is a similar substance, obtained from the air-bladders of a species of sturgeon, and *heretofore* has been prepared chiefly in Russia.

Gelatine softens and swells in cold water, but scarcely dissolves until the water be heated; on cooling, it forms a tremulous jelly. An ounce of water will dissolve, when hot, about three grains without gelatinizing on cooling. It is somewhat analogous to albumen, but does not form any compound with the oxide of silver, as the latter does; hence its different action.

Gold.—Chloride of Gold when in solution is a bright yellow colour when diluted, but a deep red when concentrated. In the solid state it is a red deliquescent mass, without any apparent regular formation; and, although chemically neutral, it is acid to test-paper. Its chief use in photography is the property it possesses of blackening the shadows of a positive print, which it does to a wonderful extent. It is easily decomposed by sulphurous acid, charcoal, and many of the vegetable acids; also by protosulphate and protonitrate of iron. The addition of *ammonia* to perchloride of gold forms the dangerous compound "*fulminating gold.*" Hyposulphite of gold, or Sel d'Or, is a double hyposulphite of gold and soda, and is formed by the reaction of hyposulphite of soda on chloride of gold. It is very valuable in colouring positives on paper, and is very easily decomposed. It will be more fully noticed under the head of "The Colouring Bath."

Hydrochloric Acid is a volatile gas, exceedingly soluble in water, forming the hydrochloric or muriatic acid of commerce, which contains from thirty to forty per cent. of gas. It is used in the formation of chloride of gold, in combination with nitric acid, and for producing the yellow perchloride of iron.

Hydrosulphate of Ammonia is formed by passing sulphuretted hydrogen gas through ammonia. It is used for the purpose of separating silver from hyposulphite of soda, to darken negatives, and for testing solutions for silver, &c.

Hyposulphite of Soda, and the hyposulphates of gold and silver, will be fully described under the head, "The Colouring Bath."

Iodide of Potassium.—This salt, as the reader already knows, and I think there can be no objection to these facts being often repeated, is one of the salts chiefly used for the production of iodide of silver. Iodide of potassium is generally made by dissolving iodine in solution of potash until it acquires a slightly brown colour. This solution contains not only iodide of potassium, but *iodate of potash*, which may be got rid of by evaporation and heating the residue to redness, when the *iodate* parts with its oxygen and is converted into *iodide* of potassium.

Iodide of potassium has the following properties:—It forms white cubic and prismatic crystals, which should be hard, and scarcely, *if at all*, deliquescent; it is soluble in less than its own weight of water; alcohol will dissolve from two to eight grains to the drachm, according to its strength—the stronger the alcohol the less it will dissolve; *ether will not dissolve it at all.* Iodide of potassium as sold in the shops is nearly always slightly impure from the presence of carbonate and sulphate of potash.

Litmus Paper.—This is of the greatest use to the photographer, as it enables him to tell almost at once whether his solutions are acid or alkaline. It is made by soaking

porous paper in a solution of litmus, digested in hot water; the paper when dry is quite blue, but in the presence of any acid becomes red, which changes back again to blue when brought in contact with an alkali; the red litmus paper is made by dipping the blue paper in water containing one or two drops of sulphuric acid to the pint. Litmus is a vegetable substance procured from various lichens which grow on rocks near the sea.

Protosulphate of Iron is the green copperas of commerce. It dissolves in about its own weight of water, and when in solution it is used as a developer for positives on glass; it improves by use and exposure to the air, and is extensively used by photographers.

Protonitrate of Iron.—This is another salt of iron, used for the development of positives on glass; but has nothing to recommend it for use in preference to the protosulphate.

Nitric Acid is much used in the preparation of pyroxyline, for which purpose it ought to be of the strongest possible description. It is often contaminated with chlorine or sulphuric acid; the presence of chlorine may be detected by diluting the acid with an equal bulk of *distilled water*, and then adding a few drops of nitrate of silver solution—a milkiness (chloride of silver in suspension) denotes the presence of chlorine. Sulphuric acid may be detected by the addition of a little chloride of barium, which, with the sulphuric acid, will form an insoluble precipitate of sulphate of baryta.

Nitrate of Potash, or saltpetre, is a very abundant natural product. It often contains a large proportion of chloride of potassium, which may be detected by dissolving a small portion, and adding a few drops of nitrate of silver; when, if the chloride of potassium be present, the never-failing chloride of silver will be formed.

Nitrate of Lead is made by dissolving the metal, or its oxide, in excess of nitric acid diluted with two parts of water. It forms, with sulphuric acid or soluble sulphates, an insoluble sulphate of lead.

Silver Solutions.—Silver and its different solutions are all-important to the photographist.

Nitrate of Silver.—Nitrate of silver, or, more correctly speaking, nitrate of the oxide of silver, is made by dissolving pure silver in nitric acid (aqua fortis), which parts with oxygen to the silver, forming an oxide of silver, and that in turn becomes dissolved by another portion of the nitric acid. Nitrate of silver crystallizes in white scales. When the solution has been boiled down nearly to dryness, the crystals have a bitter metallic taste, and are very soluble in water, which will dissolve about its own weight. The nitrate used for photographic purposes should be dissolved in distilled water and re-crystallized, so as to be deprived of all traces of the nitric acid. A solution of nitrate of silver in distilled water is scarcely, if at all, affected by light, unless it be brought in contact with organic matter, when it becomes speedily decomposed, and thus it becomes so useful in photography; for if we wash a sheet of paper over with a solution of the nitrate of silver, and place on its surface any opaque figure, such as a coin, a leaf of a tree, or, what is better, a piece of black network, pressed to the surface by a sheet of glass, we shall, by exposure to the rays of the sun for a few minutes, obtain a correct copy of the figure; but with reversed effects, the parts uncovered being black, the parts covered remaining white. We thus form what we call a negative picture; for example—If we take three letters cut out of cardboard (Fig. 1), and place them on a piece of paper washed with a solution of nitrate of silver, press them close by means of a sheet of glass, and expose it to the sun's rays for

five or six minutes, we shall obtain a picture similar to Fig. 2, and this also is the process by which the portrait at the head of this Treatise was obtained by a very able

Fig. 1.

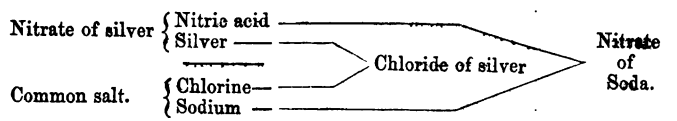
Fig. 2.

experimentalist. The negative was obtained by the usual Talbotype process, and the positive by placing the negative upon the prepared wood.

Now it is very obvious that, by removing the nitrate of silver from the white parts of the paper, and thus protecting them from any further action of light, we can, by repeating the experiment and using the negative just obtained, instead of the cardboard letters, obtain a perfect copy of the latter. This is the principle of photographic reproduction—Having once produced a negative, whether in the camera or by contact, the number of copies that may be obtained from it are almost without limit.

Nitrate of silver, when melted in a crucible, and cast into moulds giving it a shape resembling pieces of pipe stems, becomes the *lunar caustic* used in surgery; but this is scarcely pure enough for photographic purposes. It will be always better for the amateur to procure the white re-crystallized nitrate. If the nitrate obtained from the chemist or otherwise exhibit traces of nitric acid, the latter may be got rid of by heating the crystals carefully to some few degrees above boiling water for a short time. This must be done in a glass or porcelain vessel, as almost every metal has the property of decomposing the nitrate. So loosely is it combined with the oxygen that even light, as I have already shown, reduces it. If you take a solution of nitrate of silver, no matter what is the strength, and immerse in it a clean strip of copper, brass, iron, zinc, tin, or any other of the base metals, you will at once see that an action commences, the silver being thrown down as a metallic powder, and the other metal becomes dissolved; in other words, the silver has so slight an affinity (or liking) for oxygen, that the slightest force is able to separate them. This gives us another reason why silver is so very useful in photography.

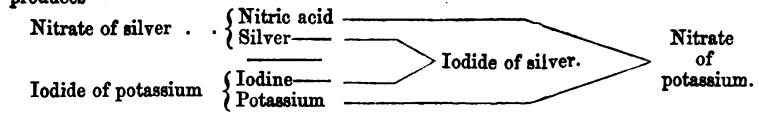
Salts of Silver.—We can very easily obtain a great many salts of silver by double decomposition. I shall explain the meaning of double decomposition by a simple experiment, and one also that is essentially photographic:—Take nitrate of silver, 30 grains; distilled, or boiled rain water, 1 ounce (when the nitrate is dissolved take in another measure); common salt (chloride of sodium), 10 grains; water, not necessary to be distilled, 1 ounce. Now, if we pour the common salt solution into the silver one, we obtain directly a white curdy precipitate, perfectly insoluble even in boiling water or nitric acid. This is chloride of silver, or a mixture of metallic silver and chlorine. The double decomposition takes place thus:—



The chlorine, having a strong affinity for the silver, joins it; and the nitric acid being

set free, very good-humouredly goes over to the sodium. We thus obtain one of the most important salts used in photographic printing. Expose the white powder to the light after washing it several times in fresh water, an operation easily performed because of its insolubility; and you will observe that it darkens all over, and presently becomes black. But do not for a moment suppose that it has blackened all through. No; the smallest possible quantity of the surface only has been acted on, the thinnest possible layer only blackened; remove the upper surface in the slightest degree, and you will find the part underneath perfectly white. Bear this fact in mind, as I shall have to refer to it more fully on another occasion.

Iodide of Silver.—This is produced in a similar way to the chloride, with the exception that we here use iodide of potassium, which by double decomposition, as before, produces—



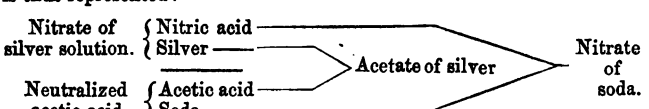
When the two solutions are mixed in the following proportions:—Nitrate of silver, 20 grains; distilled water, 1 ounce;—iodide of potassium, 20 grains; water, 1 ounce—a copious yellow precipitate is produced, which, like the chloride, is insoluble in water and nitric acid.

This salt, when perfectly pure, is not changed by the action of light; but if any excess of nitrate of silver be present, it becomes decomposed. The decomposition, in this case, has the property of proceeding onwards to blackness by the agency of the numerous developing solutions that we use, and that after the decomposition has once commenced. In this salt and the bromide of silver, being nearly alike in their nature, we observe the base of all the solutions for papers used in the camera.

Bromide of Silver.—This salt is produced in the same manner as the iodide, using bromide of potassium instead of the iodide. If you use any bromide or iodide, such as the iodide of tin, iron, zinc, mercury, cadmium, sodium, &c., you will obtain the same result, the oxygen going to the metal, the iodide or bromine going to the silver. In photographic experiments, however produced, the iodide of silver and the bromide of silver are always the same when in the solid or crystalline state.

The iodide of potassium, and the bromide also, have the power of dissolving the iodide or bromide of silver when added in sufficient quantities, a property of which we avail ourselves for the formation of iodized and brominized papers, to be explained more fully hereafter.

Acetate of Silver.—The acetate of silver will be found very useful in correcting a new nitrate of silver bath for collodion negatives, and may be made thus:—Neutralize one ounce of acetic acid by adding sufficient carbonate of soda, and add it to one ounce of distilled water, containing about 100 grains of nitrate of silver in solution. The action is thus represented:—



Hyposulphite of Silver.—This salt is formed by the action of hyposulphite of soda

on nitrate of chloride of silver, and will be more fully treated under the head of Colouring Baths. It is very soluble in an excess of hyposulphite of soda, and its chief photographic use is in connection with that salt, to impart those rich brown or purple tints so much admired in finished photographs.

Ammonia Nitrate of Silver.—This is one of the most useful and important compound salts of silver; it is extensively used in printing, and may be made thus:—Dissolve in one ounce of distilled water fifty grains of nitrate of silver, and then add, drop by drop, liquor ammonia until the brown precipitate first formed is gradually redissolved; when filtered it should be put away in a dark bottle and kept from the light.

On the Means of Recovering Silver from Old Solutions.—This may be done in various ways. One of the most simple of the many is to insert a strip of clean zinc or copper in the solution of silver, and let it remain until the silver is all thrown down; but old hyposulphite of soda solution, containing silver, must be treated in a different manner.

To recover silver from the latter, it will be necessary to pass a stream of sulphuretted hydrogen through the solution, or to add a sufficient quantity of hydrosulphuret of ammonia to precipitate the silver, which will be thrown down as a sulphuret in either case. The first is the most troublesome, but by far the cheapest method.

To make and pass the sulphuretted hydrogen gas you will proceed thus:—Get a large bottle, to which fit a piece of gutta percha tube bent thus (Fig. 3), which must fit in the neck or mouth of the bottle air tight, then put into the bottle about a quarter of a pound of sulphuret of iron, and about three-quarters of the contents of the bottle of water, to which has been added an eighth part of sulphuric acid (oil of vitriol), place the gutta-percha tube in its place, and the other end must go in the solution of hyposulphite of soda and silver, touching the bottom of the vessel; the sulphuretted hydrogen escaping up through the liquid decomposes its parts, and throws down the silver, the latter, as I have said, becoming a sulphuret of silver. A represents the bottle, B the vessel containing the hyposulphite-solution, C C the gutta-percha tube, D the solution of water and sulphuric acid, E the solution of hyposulphite of soda and silver, F the bubbles of sulphuretted hydrogen, and G the sulphuret of iron. The action must be continued until all the silver is thrown down, which may be ascertained by adding a little hydrosulphuret of ammonia, or by agitating the solution and smelling it; in the former case, if any silver remain there will be a black precipitate, and, in the latter, if the smell of the sulphuretted hydrogen be very strong from the liquid, it is a proof that all the silver has been thrown down. It may be as well to state here that the fumes, or gas, of the sulphuretted hydrogen is very poisonous when in a concentrated state, and, therefore, the operation should be carried on out of doors. The hyposulphite solution should be frequently stirred.

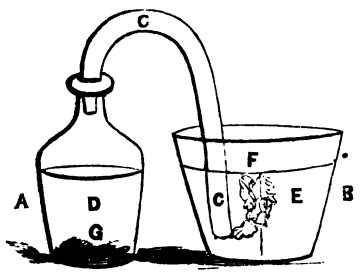


Fig. 3.

When all the silver is thrown down, it must be collected and washed on a filter by pouring water through it until the latter passes through quite clear, and will not give

a precipitate with a few drops of nitrate of silver solution; the black mass remaining may now be boiled up with nitric acid one part, water two; when all the red fumes cease to be evolved, the solution is to be diluted with water and filtered to get rid of any insoluble matter, which principally consists of sulphur with perhaps a small portion of chloride of silver and sulphuret; if the nitric acid contains any trace of chlorine, or if the insoluble portion be large in quantity, you may heat it pretty strongly on a piece of iron plate to get rid of the sulphur, and dissolve the remaining portion in a strong solution of hyposulphite of soda, and add it to the colouring hypo-bath. The solution that has been passed through the filter will be a solution of silver in nitric acid, or nitrate of silver, but will not be pure enough for photographic use; it will be better to convert it into chloride of silver by adding a solution of common salt, and washing the precipitate two or three times. The chloride, or sulphuret of silver may be converted to metallic silver by fusing it in a crucible with twice its weight of carbonate of potash, or a mixture of carbonate of potash and soda. When the heat has been carried on sufficiently, the whole flux may be poured out of the crucible, or the crucible and its contents may be allowed to cool, when the silver, a beautifully bright button, will be found at the bottom.

On the Means of Converting Chloride into Nitrate of Silver.—As we already know that nitric acid, even when boiling, will not act on the chloride of silver, we must go a little round to bring the two together, and the best method of obtaining that important result will be as follows:—After well washing the chloride, pour it out into a flat dish, in which place a bar of metallic zinc in contact with the chloride, a small quantity of oil of vitriol diluted with four parts of water is then added, until a slight effervescence is seen to take place. The dish must then be set aside for two or three days, and must not be disturbed in any manner. The reduction commences with the chloride immediately in contact with the zinc, and afterwards radiates in all directions. When the whole mass has become of a gray colour, the bar of zinc is to be carefully removed and the adhering silver washed off with a small stream of water. In order to insure the purity of the silver, a fresh addition of oil of vitriol must be made after the zinc has been removed, in order to dissolve any fragments of metallic zinc which may have become detached by accident, and after the digestion has been continued for a few hours, the gray powder is to be washed several times with water, until the water which runs off will not give a precipitate with carbonate of soda; it may then be converted into nitrate of silver by boiling with nitric acid one part, water two, and evaporated to crystals. The above formula is not so expensive or troublesome as the fusing with carbonate of potash. Bear in mind, that you must pour the oil of vitriol into the water, and the vessel in which they are mixed must be such as will *stand heat.*

Oxide of Silver is an olive brown powder obtained by adding potash to nitrate of silver. It is soluble in hyposulphite of soda, cyanide of potassium, ammonia, and nitrate of ammonia.

Sulphuric Acid, or oil of vitriol, is an acid possessing intense chemical powers, and readily displaces the greater number of acids from their salts; it clears organic substances by depriving them of water, and converts alcohol into ether by the same means, and is one of the elements used for the production of gun-cotton. Its action in the latter case will be more fully explained further on.

Tetrathionic Acid.—(See "Colouring Bath.")

ON THE OPTICS OF PHOTOGRAPHY.

Action of Light.—Having, for the present, finished the necessary remarks on Photographic Chemistry, I shall proceed to explain the optical and actinical (or chemical *decomposing* ray power) action of light on surfaces prepared photographically; and I may remark, *en passant*, that, but for our knowledge of the chemical action of light through glass, all our chemical knowledge of the theory of photography would be perfectly useless; we could no more obtain a perfect copy of a tree, a house, or a hay-stack, than we could fly—this being another proof, if such be necessary, of how dependent one branch of science is on another.

Light, the agent by which we are enabled to depict nature or art with an accuracy that baffles the most experienced artist, is derived from the sun. True it is that there are other sources of light; but at present we have nothing to do with them—we must confine our attention to solar light, and the chemical change it produces. This glorious light, which

> "Was given to quicken slumbering nature,
> And lead the seasons' slow vicissitudes
> Over the fertile breast of mother earth,"

now pours forth its beams, and in a sense not dreamed of by the poet, dispenses

> "Life and light on every side;
> Brightening the mountain cataract, dimly spied."

And yet how little do we know of the nature of a sunbeam. A solar beam of light is a bundle of rays, a ray being the smallest portion of light which can emanate from a luminous body. Each of these rays possesses distinctive characters, both as regards their chemical functions and colours. Sir Isaac Newton proved that the white light emitted from the sun is not so simple as it appears, but is composed of vivid colours and tints which we may prove to our own satisfaction, by performing the beautiful experiment called "Newton's Analysis of Light," being a prism (Fig. 4), or triangular mass of glass, which is so contrived that it may be adjusted to any angle, or placed in any required position. The shutters of the room being closed, we may admit a ray of light either by boring a hole in the shutters or separating them a little.

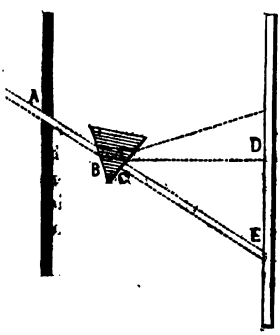


Fig. 4.

The ray of light A E (Fig. 4), being admitted into the darkened room by means of a hole A in the shutter. It will be seen that the space between the shutter and the spectator is traversed by the sunbeam or ray of light, which appears to cause little particles of dust to dance in the atmosphere of the room. This appearance, however is owing to the illuminating power of the sunbeam contrasting with the other darkened or non-illuminated space in the room, which renders the small particles of dust floating in the air visible. As soon as the prism B C (Fig. 4) is placed in the path of the sunbeam, so as to allow it to fall on one of its angles B, the ray will be refracted, or bent out of its course, so as to pass towards the back of the prism (as in the line D), and not in the same line A E that it would otherwise have

done, had not the prism been interposed. Another effect also takes place: an elongated delicately-coloured image is formed upon the wall D E; and if you stand at a short distance from the prism you will see that these colours are spread out in a triangular form, the base of which is on the wall, and the apex, or point of origin, at the back C of the prism. Remove the prism, and it is seen that the splendid display of colours upon the wall has disappeared, and a round spot of white light E is seen below the place occupied by the solar spectrum.

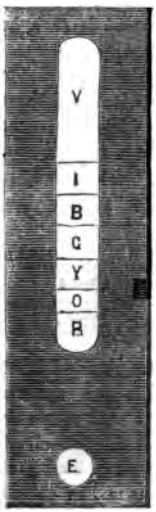


Fig. 5.

The coloured image upon the wall is called the *prismatic* or *solar spectrum*, which, according to Sir Isaac Newton, is composed of seven different colours (Fig. 5). The colour at the lower portion of the image, or that nearest to the round white spot E on the wall when the prism was removed is of a red colour, and the one at the other end is of a violet colour; the whole intermediate parts being occupied by five other colours, and the whole arranged according to the table exhibited below, the proportion of each colour having been measured by Fraunhofer with the greatest care, with the results placed opposite to each corresponding with the 360 degrees of a circle, the red ray being the least, and the violet the most refracted of this chromatic image:—

Top.	
Violet	109
Indigo	47
Blue	48
Green	46
Yellow	27
Orange	27
Red	56
Bottom.	360

Since Newton's time, various experiments have been instituted and other rays detected; for instance, a crimson or extreme red ray has been discovered below the red ray, by examining the solar spectrum through a deep blue glass; and Sir John Herschel observed a lavender beyond the violet ray, by throwing the spectrum upon a piece of yellow paper. Mr. Stokes has also proved the existence of an extra spectral ray far beyond the violet; but, as we have remarked before, our consideration of light does not extend beyond its practical use to photographers.

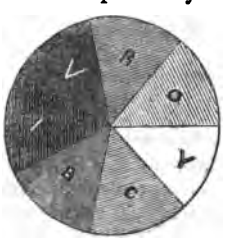


Fig. 6.

Sir Isaac Newton was of opinion that white light was composed of seven primary rays, each possessed of a certain degree of refrangibility, or capability of being turned out of its natural course; and he also considered that the colour of a ray indicated its angle of refraction. Sir David Brewster has demonstrated that the seven primary colours, as Sir Isaac Newton called the rays of the solar spectrum, are not primary, but that only three of them are so—viz., blue, yellow, and red; the rest are compounds of the three primary colours, which form the spectrum by overlapping each other; and these are explained in the annexed diagram (Fig. 6).

Such are a few of the phenomena relating to light regarded by the philosphers; its application to photography are as follows:—

Of the real nature of the rays, which form the sunbeam, little is known. The theory of Newton consisted in supposing the ray of light was produced by the emission of minute particles of matter travelling at an enormous velocity from a luminous body, and, when these minute particles impinged on any body, they were either thrown back, reflected, or absorbed, according to the surface on which they fell.

These particles entering the human eye, produce the sensation of light on the retina, which sensation is conveyed through the optic nerve to the brain.

The theory of the celebrated Huygens pre-supposes that the space beyond our atmosphere, and the interstices between the molecules, or ultimate atoms of all bodies, are filled with an imponderable ether, and that light is produced by the oscillation or vibration of this ether, which undulation is set up by some self-luminous body—of course, the sun.

Another theory may here be mentioned, although but very slenderly supported—namely, that set forth by Oersted, who considered that light was the effect of a rapid succession of minute electrical discharges taking place between a luminous body and the eye. Leaving these theories, however, to the philosopher, let us see how they affect the photographer.

The sunbeam—the ray of white light—contains powers within it of which the earlier philosophers had but a faint idea; besides its accompanying heat, there is a principle associated intimately with it, which has the power of decomposing and of determining the recomposition of chemical compounds. This principle has been already alluded to—it is "Actinism," and is as perfectly distinct in the nature of its properties. from light, as light is from the principle of heat, with which it is also closely connected.

Actinism may then be considered as the fundamental principle on which photography is based; and we would wish, before entering on a description of the various methods of obtaining sun pictures, to draw a broad distinction between light and actinism, more especially as many apparent difficulties present themselves, and seem almost insurmountable until tried by the principle we are about to lay down.

From what has been said, it will be supposed that what we consider light exerts a decided influence over certain chemical salts having a metallic base; but it now becomes necessary to show that light does no such thing—it is not *light*, but *a componant part of light* which exerts this influence. In order to explain this seeming anomaly, let us consider the subject a little more carefully. A ray of white light consists of the three primitive colours—blue, yellow, and red; and their combinations forming, *en tablette*, the following:—Violet, indigo, blue, green, yellow, orange, red; these colours and shades being produced by the decomposition of white light by means of a prism. Of these shades, the *violet* has the greatest reducing or decomposing power. By this, I mean that the *violet* part of the decomposed portion of light exerts the most powerful influences on the unstable metallic salts, reducing them to their bases. This action is the *actinic* of the photographers; and the study of the action itself may be properly designated as *actinic-chemistry*. Every beam of light which we receive from the sun is composed of the three primary colours; these blending one with the other, form shades or *mixtures* of the three; thus we get four shades independent of the primitive colours, viz., indigo from blue and violet, green from blue and yellow, orange from yellow and red.

It may be asked, where does the violet come from? It is easily accounted for

thus—if we decompose a single ray of white light, we get the following component parts by means of the prism :—

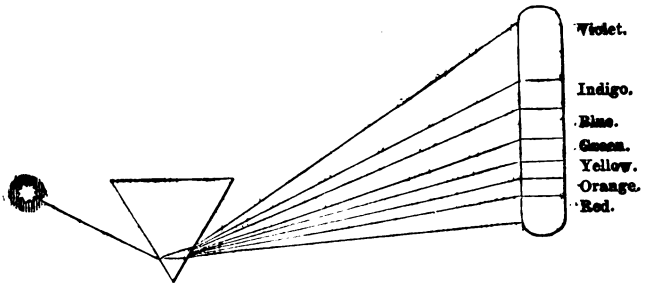


Fig. 7.

Now, if we decompose another ray, just below the above, we get the same parts reproduced, thus—violet comes first, or next the red, and is evidently produced by the mixture of red and blue (the next primary colour), or, more properly speaking, by the mixture of a deep red, which slightly extends lower than the red of the visual spectrum, with the indigo of the ray immediately above the under one; now this ray, or portion of a ray, has the power of more perfectly decomposing the unstable salts of silver than any other of the series; and, therefore, has acquired the term *actinic ray*.

The actinic power, and the light-giving power, may be more fully explained in the following diagram :—

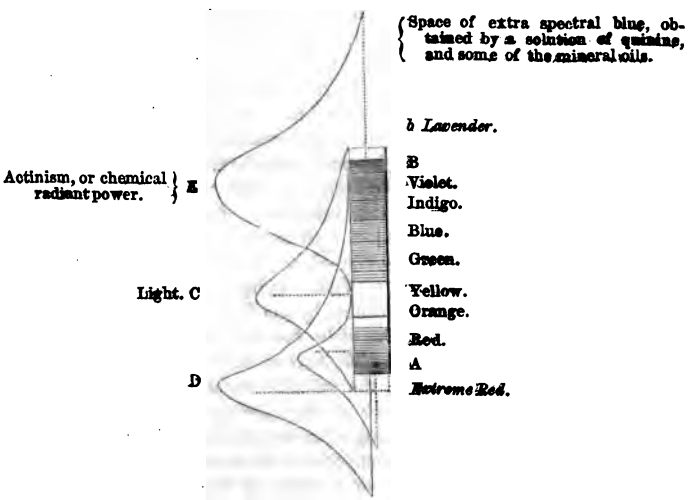


Fig. 8.

In the above diagram, the greatest actinic, or chemical action, is shown opposite

the violet ray E, and the least opposite the mixture of the yellow and orange C; below the red at A the actinic power becomes active again, because the extreme or deep red is about to pass into the violet with the indigo of the blue in the ray next below; at the same time, the part of the ray giving the brightest light is opposite the yellow and orange light C. We observe, also, that the point giving the greatest heat is just below the red D; but with that we have nothing to do. We thus ascertain that the chemical, or photographic action is confined, as already stated, to only a portion of the visual ray of light.

To speak more plainly, certain colours or shades act more powerfully than others, which can be proved by the following simple experiment:—Prepare a sheet of paper thus—float it on a weak solution of common salt, say ten grains to the ounce, and when dry, float it again on a solution of nitrate of silver, say thirty grains to the ounce. This must be done and the sheet dried while it is protected from white light. When dry, place on it three pieces of coloured glass, viz., red, yellow, and blue; expose the whole to the sun's rays for a short time, when it will be found that the paper has become rapidly discoloured under the blue glass, but remains unchanged under the red and yellow, although the last is by far the most transparent. This property of red or yellow colours of intercepting the actinic rays of light, we make the greatest use of in photography; but this subject will be treated of more fully under the head of "The Dark Chamber."

A ray of light is always more or less refracted or bent, depending on the density of the medium or substance through which it passes. The refractive power of some substances is immense, while that of others is very trifling, as the following table of some of the most important will show:—

Air	1·000294	Plate glass	1·542
Water	1·336	Flint glass	1·830
Alcohol	1·372	Do. containing much lead	2·028
Oil of cloves	1·535	Diamond	2·439
Crown glass	1·534		

A ray of light, passing through a vacuum, progresses in a perfectly straight line, and were it possible, under such conditions, to look at a brilliantly illuminated point, we should see it in its true position, viz., the numerous rays coming undisturbed directly to the eye. But all matter, however attenuated it may be, has the property of refracting or bending the ray of light; consequently we do not see the stars in their true position, owing to the refractive power of the atmosphere.

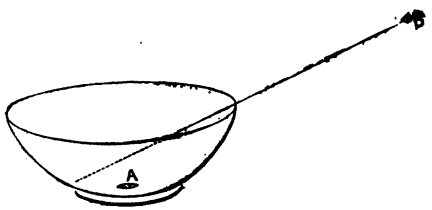


Fig. 9.

The law of refraction can be easily and decidedly demonstrated thus—take a basin, in the bottom of which place half-a-crown, or any other small bright substance, and removing a sufficient distance from it to lose sight of the coin, it will appear as in Fig. 9; A representing half-a-crown, and B the eye of the observer. The half-a-crown, of course, is invisible. Then request some person to pour water into the basin, taking care to keep your eye

fixed on the same spot during the operation. The half-a-crown begins to appear, and gradually becomes more visible until it comes entirely into view. This fact is owing to the ray of sight (or light) being refracted, or beaten back, as in Fig. 10; C representing the water, and B A the ray of light refracted.

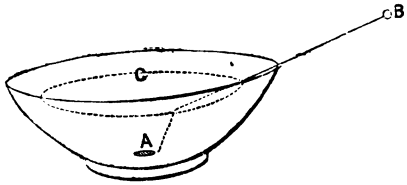


Fig. 10.

The explanation of this phenomenon is, that the ray of light producing vision in the eye is bent, on emerging from the water, and has all the effect of conveying our sight round a corner.

The refractive power of water is also observable when we thrust a straight stick or instrument into it, on aiming at any object. We see that the stick seems to be bent, and fails in reaching the point which we desired it should reach. On this account, the aim by a person not directly over a fish, must be made at a point apparently below it, otherwise the weapon will miss by flying too high. Persons who spear salmon in rivers require to calculate upon this refractive power in taking their aim.

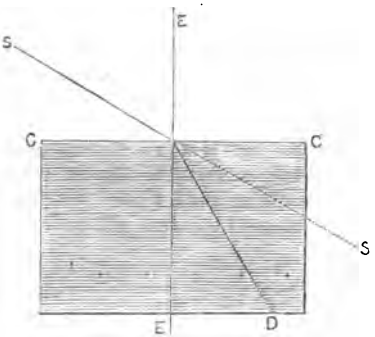


Fig. 11.

Another illustration of refraction is to allow a sunbeam S (Fig. 11), passing through a hole in the window-shutter of a dark room, to fall upon the surface of a fluid contained in a glass vessel, C C; instead of proceeding onward to D, it will be found to alter its course at the surface of the fluid, and pass along the line to D. Every substance has different refractive powers in virtue of its physical constitution; but a ray of light incident perpendicularly on a refracting medium, as the ray E (Fig. 11), suffers no refraction.

Again, if we float, one upon the other, fluids, B, C, D, having different powers of refraction, we shall then see the relative phenomena exhibited by the bending of the ray B B, as it passes through these different media, as represented in Fig. 12.

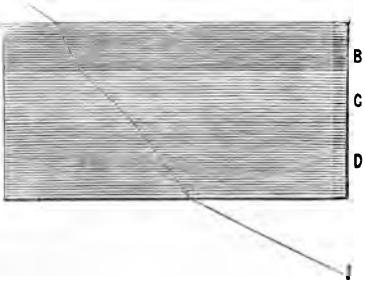


Fig. 12.

The mode of the refraction depends on the comparative density or rarity of the respective media. If the medium which the rays enter be denser, they move through

it in a direction nearer to the perpendicular drawn to its surface. On the contrary, when light passes out of a denser into a rarer medium, it moves in a direction farther from the perpendicular. This refraction is greater or less—that is, the rays are more or less bent, or turned aside from their course—as the second medium through which they pass is more or less dense than the first. To prove this in a satisfactory manner, and at the risk of repetition, we make the following experiment:—Take an upright empty vessel into a darkened room, which admits but a single beam of light obliquely through a hole in a window shutter. Let the empty vessel stand on the floor, a few feet in advance of the window which admits the light, and let it be so arranged that, as the beam of light descends towards the floor, it just passes over the top of the side of the vessel next the window, and strikes the bottom on the side farthest from the window. Let the spot where it falls be marked. Now, on filling the vessel with water, the ray, instead of striking the original spot, will fall considerably nearer the side towards the window. And if we add a quantity of salt to the vessel of water, so as to form a dense solution, the point where the ray strikes the bottom will move still nearer to the window. In like manner, if we draw off the salt water, and supply its place with alcohol, the beam of light will be still more highly refracted; and oil will refract yet more than alcohol.

Our next care is to study the practical application of these laws of refraction to the manufacture of "lenses." By lens is meant what is commonly called a magnifying glass, which may be composed of any transparent substance; but in its application to photography it is generally made of glass as pure and colourless as can be procured, therefore we shall consider that a lens is a glass ground into such a form as to collect or disperse the rays of light which pass through it. These are of different shapes, and thence receive different names. The following figures individually represent sections of the variously-shaped lenses and other glasses used in optics. A is a trian-

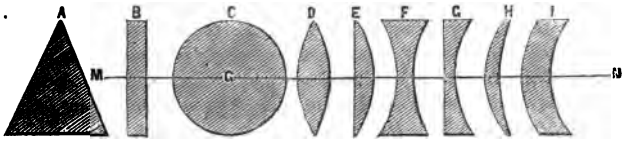


Fig. 13.

gular stalk of pure glass, of which we have here a cross sectional or end view, and which is called a prism. Each side of the prism is smooth. B is a section of a piece of plane glass, with sides parallel to each other. C is a sphere or ball of glass, and consequently is convex on all parts of its surface. D is a piece of glass convex or bulging on its two sides, and is called a double convex lens. It is this kind of lens which is used for magnifying objects, in spectacles, telescopes, and other instruments. E is a plano-convex lens, flat on one side and convex on the other. F is a double concave lens, or glass hollowed on each side. G is a plano-concave lens, or planed on one side and concave on the other. H is a meniscus, or lens convex on one side and concave on the other, both surfaces meeting, and of which we have an example in watch-glasses. I is an example of the concavo-convex lens, in which the surfaces disagree, or do not meet when continued. In all these lenses an imaginary line, re-

presented by M G N, and passing through the centres of the surfaces, is called the axis. Thus, the line said to pass through the centre of any lens, in a direction perpendicular to its surface, is called its axis.

The design in forming lenses is to procure a medium through which the rays of light from any object may pass, and converge to a corresponding point beyond. The manner in which the rays proceed through the glass, and then centre in a focal point, will depend on the form of the lens, its capacity for refraction, and the distance of the object.

If we take a piece of glass, flat on one side and cut into different faces on the other, and then look through it from the flat side at any object—for instance, a pea—we shall see as many peas as there are faces receiving rays from the single pea. We may exemplify this principle of multiplication by the annexed figure (Fig. 14), in which A B is a lens flat on one side, and cut into three faces on the other, G H. Y is the eye of the spectator, and P the pea to be looked at. The eye receives a pencil of rays direct through the lens at I, and sees the object without refraction. A pencil also proceeds from P to face G A, and another pencil proceeds from C to the face H B, and in both cases the rays are bent and refracted to the eye. This eye, however, does not recognise the path of either of these oblique rays, but perceives the image of a pea at D and at E; and thus three peas seem to be seen in place of only one.

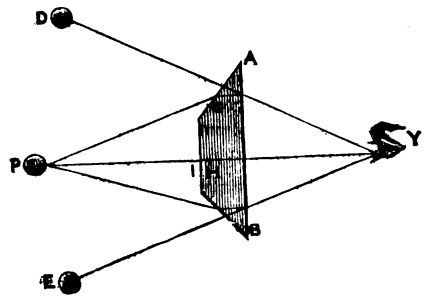


Fig. 14.

In smoothly ground lenses, in which there are no distinct faces to multiply the images of an object, the rays bend, as we have said, so as to meet in a corresponding point beyond them. A lens may consist of a perfect globe of glass, or globe filled with pure water, in which case the refractive power will be considerable. A double convex lens, which is the more common kind, may be viewed as a portion cut out of the side of a sphere, as seen in Fig. 15. Here, as in all cases of convexity, the focus of the parallel rays passing through the lens is at F, which is the centre of the sphere, of which the farther, or anterior side, is a portion, or a point at half the diameter of the sphere from it. (Half the diameter is technically called the *radius*.) Should we take a plano-convex lens, the focal point would be considerably different. In Fig. 16 we have an example of this kind of lens, which evidently possesses only half the refractive power of the double convex glass. Here the parallel rays, falling on the convex side of the lens, are seen to converge at the distance of the whole diameter of the sphere. Thus, the focal point at which the rays of light fall is always regulated by the degree of curvature of the lens. I shall illustrate this by various diagrams, and ask the reader's careful attention, for the subject is difficult, and cannot be comprehended by a superficial glance.

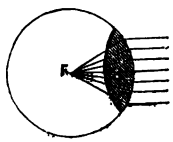


Fig. 15.

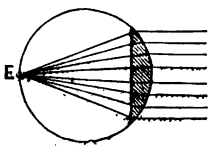


Fig. 16.

We take a double convex lens, represented by A B C (Fig. 17), the axis of which is the line G′ C D′. The ray D′ G′, being straight through the centre, suffers no refraction; but the rays D A and D″ B are refracted, so as to meet at the focal point G′. We now observe that the parallel rays E A, E′ C, and E″ B, and also F A, F′ C, and F″ B, falling obliquely on the lens, will, in a similar manner, be refracted, and have their foci at G and G″, at the same distance from the lens. Those lines which pass through the centre, as E′ C G″ and F′ C G, do not alter their direction, not being refracted. Thus, in whatever way parallel rays pass through a lens, we have a focal point beyond it, be it straight forward or in an oblique direction.

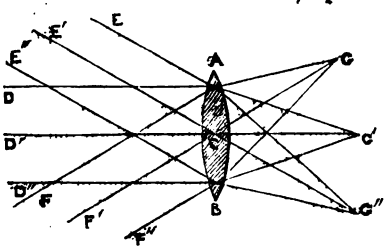


Fig. 17.

The distance at which the rays meet beyond the lens is exemplified in the next diagram (Fig. 18). Dr. Arnott, in his Treatise on Physics, says—"Rays falling from A

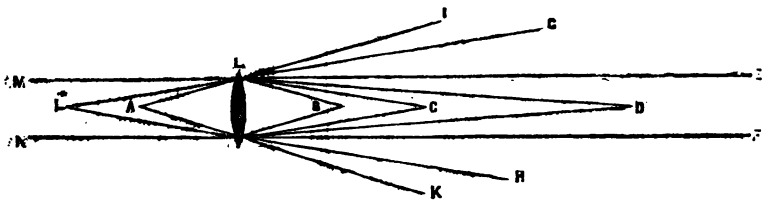


Fig. 18.

on a comparatively flat or weak lens at L, might meet only at D, or even farther off, while, with a stronger or more convex lens, they might meet at C or at B. A lens weaker still might only destroy the divergence of the rays, without being able to give them any convergence, or to bend them enough to bring them to a point at all, and then they would proceed all parallel to each other, as seen at E and F; and if the lens were yet weaker, it might only destroy a part of the divergence, causing the rays from A to go to G and H, after passing through, instead of to, I and H, in their original direction.

"In an analogous manner, light coming to the lens in the contrary direction from B C D, &c., might, according to the strength of the lens, be all made to come to a focus at A or at L, or in some more distant point; or the rays might become parallel, as M and N, and therefore never come to a focus, or they might remain divergent.

"It may be observed in the annexed figure, that the farther an object is from the lens, the less divergent are the rays darting from it towards the lens, or the more nearly do they approach to being parallel. If the distance of the radiant point be very great, they really are so nearly parallel that a very nice test is required to detect the non-accordance. Rays, for instance, coming to the earth from the sun, do not diverge the millionth of an inch in a thousand miles. Hence, when we wish to make experiments with parallel rays, we take those of the sun.

"Any two points so situated on the opposite sides of a lens, as that when either becomes the radiant point of light, the other is the focus of such light, are called conjugate foci. An object and its image formed by a lens, must always be in conjugate foci; and when the one is nearer the lens, the other will be in a certain proportion more distant.

"What is called the *principal* focus of a lens, and by the distance of which from the glass we compare or classify lenses among themselves, is the point at which the sun's rays—that is, parallel rays—are made to meet; and thus, by holding the glass in the sun, and noting at what distance behind it the little luminous spot or image of the sun is formed, we can ascertain the solar focus of a glass, as at A for the rays E and F."

From the preceding explanations it will be understood, that when an object is placed at any distance from a lens, an image of it will be formed in the corresponding conjugate focus; but to see this image distinctly, the eye must generally be placed at least six inches behind it, that is, farther from the lens. When, however, the object is placed in the principal focus, the rays are refracted parallel, and the image in this case is distinct when seen at any distance. But the most remarkable quality of a double convex lens remains to be noticed; we allude to its magnifying power. This quality is entirely a result of the refractive power of the glass; embraced within the sphere of the rays from the lens, the object is apparently expanded in size, and seems brought nearer to the eye. This may be elucidated, for small objects seen near, by a reference to the diagram (Fig. 19.)

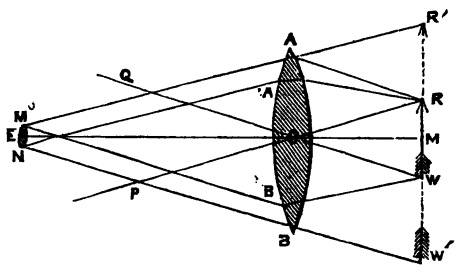


Fig. 19.

Let E be the eye, and M N the diameter of its pupil, R W a small object placed at the least distance of distinct vision (about six inches from the eye for small objects), and let R W be its apparent size when seen by the unaided eye. If a convex lens A B is now interposed between the eye and the object, so that the object R W shall be in the principal focus of the lens, an enlarged image R' W' of the arrow will then be seen, its extremities R' W' lying in the directions E A, E B. The directions of these rays are determined thus:—From R and W draw the central rays R C P, W C Q, through the centre C of the lens; then the rays of the conical pencil, proceeding from the point R to every point of the nearer surface of the lens, are refracted in such a manner by the lens, that they all emerge in directions parallel to the central ray R C P; but of the whole refracted pencil only a small portion enters the eye, namely, the pencil A M N A, limited by the size of the pupil M N; and the head A of the arrow, whence this pencil proceeds, appears to lie in the direction of the pencil E A R' at R'. It is shown exactly in the same manner, that the point W will appear in the direction E B W' at W'. The enlarged image of the small arrow R W is therefore R' W'. The proportion in which the image is enlarged will be easily ascertained thus:—The triangles E R' W', C R W, are similar, and therefore the ratio of R' W' to R W, is that of E R' to C R, or of E M to C M; that is, as the least distance E M of distinct vision, to the focal length C M of the lens. If, therefore, the least distance of distinct vision

be divided by the focal length of the lens, the quotient will be its magnifying power. If E M be reckoned 6 inches for small objects, and if the focal length C M be 2 inches; then, since 6, divided by 2, gives 3 for a quotient, the magnifying power is 3 times. If C M were one quarter of an inch, then 6, divided by ¼, gives 24 for a quotient, and the magnifying power would in this case be 24 times.

A more simple explanation may be attempted as follows:—Turn to Fig 14, representing the lens with three faces on one side and flat on the other. There it is observed that the vision travels in the direction of the ray from the object, as it passes through the glass, and therefore sees an appearance of three objects. Now, in the above case of a magnifying lens, the vision in the same manner travels from the eye at E in the direction of the angle of refraction; it goes on to R′ and W′, and thus the actual object being drawn out, as it were, to meet these points of vision, or seemingly expanded by the bent rays, we of necessity see an apparently larger object. If the glass were cut in faces, instead of being smooth, the object would not appear drawn out, but would be multiplied in as many points as there are faces.

The inversion of the image by a lens may be illustrated by the diagram, (Fig. 20.) A B C is an arrow, with the point uppermost, placed beyond the focus at F, of a double convex glass *d e f*. In virtue of the refractive power of the lens, the rays which proceed at A meet at Z, and form an image of the arrow-point inverted; while the rays from C meet at X, and form a similarly inverted image of the feather part of the arrow. The rays proceeding from B unite at *b*. Here, only rays from A, B, and C are represented, for the sake of clearness; but, in point of fact, rays from all parts of the object proceed through the lens, and hence an entire image is formed in an inverted position. Should the object A B C be brought nearer the lens, the image will be removed to a greater distance, because then the rays are rendered more divergent, and cannot so soon be collected into corresponding points beyond. To procure a distinct image, the object must be removed farther than the focal point F from the glass. In this exemplification, the object seems to be diminished; but if we make the small arrow the object, the larger one will be the image of it magnified.

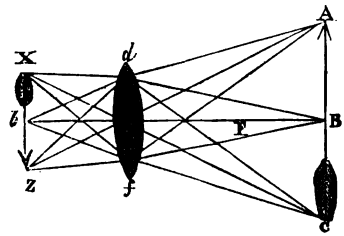


Fig. 20.

In order to explain the power of lenses in magnifying distant objects, and bringing them near us, let us suppose an object placed at one hundred feet distance from the eye of a spectator. Let us place a convex glass of twenty-five feet focal distance half way between the object and the eye; then, as has been previously observed, an inverted image of the object, and of the same size, will be formed fifty feet behind the lens. If this picture is looked at six or eight inches behind it, it will be very distinctly seen, and nearly as well as if the object itself had been brought to within six or eight inches of the eye of the spectator. If, however, instead of a lens of twenty-five feet focal length, a lens of a shorter focus is made use of, and so situated with respect to the eye and the object that its conjugate foci are at the distance of twenty and eighty feet from the lens—that is, the object is twenty feet before the lens, and its image eighty feet behind it—then the size of the image will be four times that of the object. If the eye, therefore, looks at this magnified image six inches behind it, it will be seen

with great distinctness. In this case the image is magnified four times directly by the lens, and 200 times by being brought 200 times nearer the eye; so that its apparent magnitude is 800 times larger than before. At distances less than the preceding, the rule for finding the magnifying power of a lens, when the eye views the image which it forms at six inches distance, is, according to Sir David Brewster, as follows:—"From the distance between the image and object in feet, subtract the focal distance of the lens in feet, and divide the remainder by the same focal distance. By this quotient divide twice the distance of the object in feet, and the new quotient will be the magnifying power, or the number of times that the apparent magnitude of the object is increased. When the focal length of the lens is quite inconsiderable, compared with the distance of the object, as it is in most cases, the rule becomes this:—Divide the focal length of the lens by the distance at which the eye looks at the image; or, as the eye will generally look at it at the distance of six inches, in order to see it most distinctly, divide the focal length by six inches, or, what is the same thing, double the focal length in feet, and the result will be the magnifying power."

Having given the laws of optics sufficient notice, we shall next consider that portion which is more intimately connected with photography. One of the first objects to be considered in the manufacture of a lens for photographic purposes, is to produce one with the least *spherical aberration*. Now, if we take a double convex lens and produce the image of a figure (Fig. 21), we observe that the produced image is curved; and a little consideration will show that it is not possible that such a curved surface as that represented could produce an image of equal distinctness over every part of a plane surface: the rays cannot meet, as they are refracted from curved surfaces along any straight line; and supposing we receive on the surface of a lens a bright circular image, it will be brilliant and well defined around the centre, the light becoming fainter towards the edge, and at length passing into a cloudy halo, exhibiting the prismatic colours.

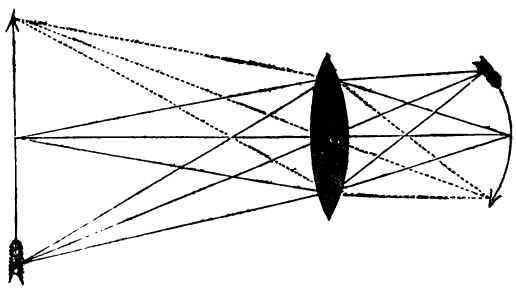


Fig. 21.

This is called *spherical aberration*, and to it is due that want of distinctness which commonly is found around the edges of pictures taken in the camera obscura.

It is, therefore, important, in the selection of lenses, that we look for sharpness of definition over the whole of a perfectly flat field. But by attention to the two facts, that a lens, one surface of which is a section of an ellipse, and the other of a circle struck

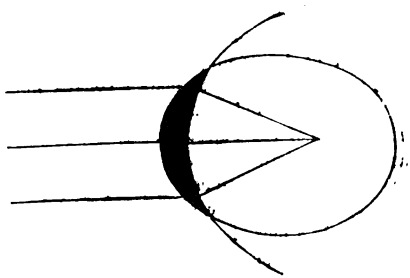


Fig. 22.

from the farthest of the two foci of that ellipse, as in Fig. 22, produces no aberration, much may be effected. A lens of this form, therefore, with a convex surface, part of an ellipsoid, the focal distance of which coincides with its farther focus, and a concave surface, part of a sphere, whose centre is that focus, will meet all our requirements. The mechanical difficulties of producing such lenses are great, but they may, by cautious manipulation, be to a great extent overcome.

If we take such a lens as we have been describing, and stop its centre with a blackened disc, leaving only a small portion of the edge for the light to pass through, and throw its image on a screen, we shall find it bordered with fringes of colour. At one distance red will prevail, at another violet. This is the result of chromatic aberration, and arises from the unequal refrangibility of the dissimilar rays. The red ray

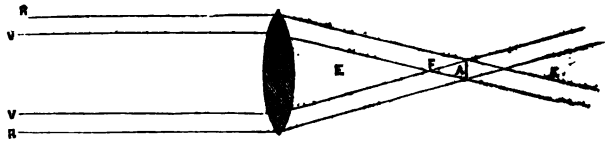


Fig. 23.

is less bent than the violet; consequently, supposing the rays R R (Fig. 23) to fall on the edge of a lens, they will converge to a point at F, whereas if the rays V V fall along the same circular line, they will, being more refracted, meet at F. Now if we place a disc at E, just the size of the cone of light, it will be edged with violet; but if we move it to A, the coloured border will be red.

By the table of the refractive powers of transparent bodies (page 119), it will be seen that, for a beam of white light, the difference between the most refractory flint glass and crown glass, in their refracting powers, is as 2·028 is to 1·534; and this proportion is maintained nearly, but not exactly, for all the coloured rays. If, therefore, we have a crown glass lens, the refractive power of which will place the focus at *a* for the violet rays, and at *b* for the red rays, and we grind to fit it a flint-glass lens, the refracting power of which would place the foci of the rays at *c*, *d* (Fig. 24),

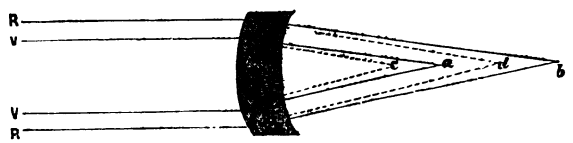


Fig. 24.

it will be seen that the result of such a combination would be the formation of a colourless image at a mean point between them, by *re-combining* the rays into white light; and such becomes the achromatic lens of the camera. In fact, to combine the violet and blue rays with the less refrangible red is all that is required; for this reason:—Suppose there be two prisms B F C and C D F, placed in juxtaposition and

turned in contrary directions, as in Fig. 25. If we first assume these prisms to be of the same substance, the refracting angle C F D of the second being smaller than the refracting angle B C F of the first, the two prisms will produce the same effect as one prism B A F; that is, the white light which passes through them will not only be bent, but decomposed. But if the first prism B C F be made of crown glass, and the second of flint, we can destroy the dispersion, while preserving the refraction. The flint being more dispersive than the crown, and the dispersion produced by a prism diminishing with the angle of refraction in the prism, it follows that in suitably diminishing the angle of refraction C F D in the flint prism, with relation to the angle of refraction B C F in the crown prism, we can render the dispersive power of these two prisms equal; and as from their position the dispersion occurs in opposite directions, it is *compensated;* that is, the emergent rays E O are obviously reduced to a parallelism, and consequently give white light.

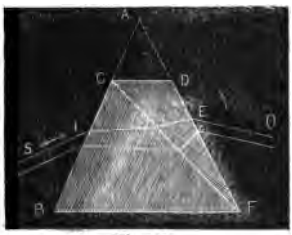


Fig. 25.

The relation of the angles B C F and C F D, however, which bring to a parallelism red and violet rays, not having the same effect on the intermediate colours, it follows that with two prisms we can in reality *achromatize* only two rays of the spectrum; so that, in order to obtain perfect achromatism, it would be necessary to have seven prisms, of substances unequally dispersive, and whose angles of refraction should be suitably determined.

So that one cause of rapidity in a lens is the perfection of the coincidence of the chemical and visual foci. Another cause, is the shortness of the focus. The greater length of focus possessed by a lens, the larger the picture produced, as a lens is generally calculated to cover, that is, have an uniform action over two-thirds its length of focus; or, to explain more fully, a lens of twelve inches focus will cover eight inches square, or nine by seven. It may seem strange that a lens that will cover nine by seven, could not cover nine by nine, but a little reflection will prove the contrary. Thus, if we draw a circle of the size properly covered by a twelve inch focused lens, and make a square, as represented by the solid lines (Fig. 26), we can observe that by taking an inch off one side we may add it to the other, or nearly so—the change being represented by the dotted lines— and that without going out of the circle; so that a lens of twelve inches focus covering eight square inches, would not be half as rapid as a lens of six inches focus, covering four square inches. The amount of light reflected from the same object being four times as much in one case as in the other. To copy an object requiring to be done quickly, we must therefore use *two large* lenses, placed some distance asunder, by which the length of focus is diminished and the rapidity is increased; the back lens catching the refracted rays of the front one, and refracting them still more. We thus obtain what is called a double lens, or more properly a double combination of lenses, as shown in Fig. 27.

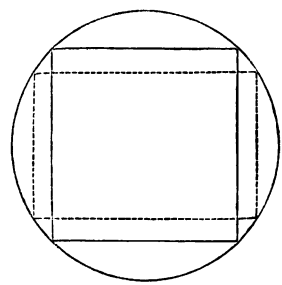


Fig. 26.

Combinations of Lenses.—These combinations can be obtained so as to take both portraits and views. The lenses for portraiture are arranged as represented in Fig. 27. If the lenses are removed from the cells, especial care must be taken to replace them in their former position, thus:—The flattest side of the lens B, the concave side of the inner lens A, and the least convex side of the outer lens A, must be turned towards the interior of the camera, and the ring of brass must be placed between the two lenses A so as to separate them. If views, pictures statuary, &c., are to be taken, the cell containing the lens A must be unscrewed and removed; the hood E and the cell containing the lens B must be unscrewed; the sliding tube holding the lens is now to be pulled out of the cell, and one of the circular plates of metal with a central aperture (called a stop) dropped into its place; the tube holding the lens is now reversed and pushed in so that the convex side of the lens is towards the interior of the camera, and the whole arrangement as represented by Fig. 28, where C is the sliding tube, B the lens, and D the stop. Three stops with different sized apertures belong to each set of lenses; but which is to be selected for use in any particular case, must depend on the judgment of the operator. In dull weather, and in copying objects indifferently illuminated, the largest size aperture stop is used; the middle size stop is for general use in moderate light, and the smallest size where the object to be copied is exposed to full sunshine or where great sharpness is required; it may be taken as a general rule, within certain limits, that the smaller the aperture which admits the light, the greater is the sharpness of the picture produced, but the time of exposure must be increased where such small apertures are employed.

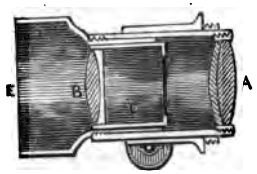


Fig. 27.

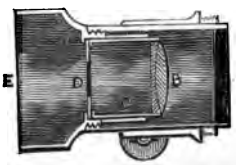


Fig. 28.

Claudet on Lenses.—The following observations on lenses by M. Claudet may not be out of place here:—"The question of the actinic focus is involved in another kind of mystery, which requires some attention. I have found that, with the same lenses, there exists a constant variation in the distance between the two foci. They are never in the same relation to each other; they are sometimes more or less separate; in some lights they are very distant, and in some others they are very near, and even coincide. For this reason I constantly try their position before I operate. I have not been able to discover the cause of that singular phenomenon, but I can state positively that it exists.

An optician, according to M. Lerebours' calculation, can at will, in the combination of the two glasses composing an achromatic lens, adapt such curvatures or angles in both that the visual focus shall coincide with the actinic focus; but he can obtain this result only for one length of focus. The moment the distance is altered the two foci separate, because the visual and actinic rays must be refracted at different angles in coming out of the lens, in order to meet at the focus given for one distance of the object. If the distance is altered, the focus becomes longer or shorter; and as the angle at which different rays are refracted remains nearly the same, they cannot meet at the new focus, and they form two images. If the visual and actinic rays were refracted parallel to each other, in coming out of the lens they would always coincide for every focus; but this is not the case. It seems, therefore, impossible that lenses can be constructed in which the two foci will agree for all the various distances,

until we have discovered two kinds of glasses in which the densities or the refractive power will be in the same ratio as the dispersive power."

Fig. 29

Before concluding my present remarks on lenses, let me tell the reader that without a good lens he need not expect good pictures; and that 'economy in a lens produces twice the outlay in other' ways. Let him not imagine, as many have—"Oh, I only want something to try with." He cannot come to a more false conclusion, as bad materials—bad lens especially—have been the cause of many a beginner never being anything else. I shall have to say something more about lenses hereafter, which will be more fully understood by the reader then than now.

Focimeters.—There is a neat little instrument made use of by most photographers for testing the lens they are about to use, and determining whether it works to focus or not; it is called the focimeter, and is the invention of M. Claudet. It is composed of fans placed at some little distance from each other, and numbered from 1 to 8. Supposing it is wished to try a lens, let the focus be tried upon say No. 4, and if that number prove to be the sharpest on the prepared plate or paper, the lens works to focus. If 2 or 3 should be sharper, then the lens must be pushed nearer to the ground glass, and the lens is not enough corrected. If, on the other hand, 5 or 6 should be sharpest, then the lens is over corrected, and must be drawn out a little more from the ground glass. There is one other quality to be looked for in a lens, and that is flatness of field. This can be easily ascertained at once by focusing on a window, when if you are using a 12-inch lens, and it gives an image of a window sash about 8 inches on the ground glass, you may be certain, if it show the bars perfectly straight, that it has a flat field, a property of the greatest importance in a good lens. Some amateurs reject a really good lens on account of air bubbles, but these are not in the slightest degree hurtful; one of the best lenses I ever saw had a dozen of them.

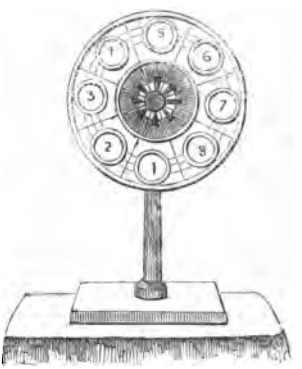


Fig. 30.

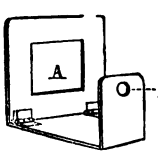


Fig. 31.

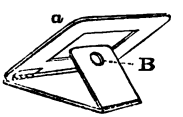


Fig. 32.

The visumeter was invented by the author for ascertaining the best position for the camera, without the trouble of putting it up. It folds up so small as to go in the waistcoat pocket. The square A (Fig. 31) is cut out, and bears a proportion to the ground glass of the camera; by looking through the small hole B we see the view, as if it were framed; Fig. 32 the same in the act of being folded.

THE PHOTOGRAPHIC APPARATUS.

The first subject coming under our consideration, agreeable with the method I intend pursuing, that of making the reader acquainted with all the details and accessories before attempting to combine them, will be

The Camera Obscura, or Darkened Chamber.—This instrument was the invention of Baptista Porta, of Padua. Its principle will be best understood by the very simple experiment of darkening a room by closing the window-shutters, and admitting a pencil of light through a small hole in them. If a piece of paper is held at a little distance from this hole, the figures of external objects will be seen delineated upon it; and, by putting a small lens over the hole, they are rendered much more evident from the condensation of the rays by the spherical glass. This will be best understood by the following diagram (Fig. 33). Let C D be a window-shutter having

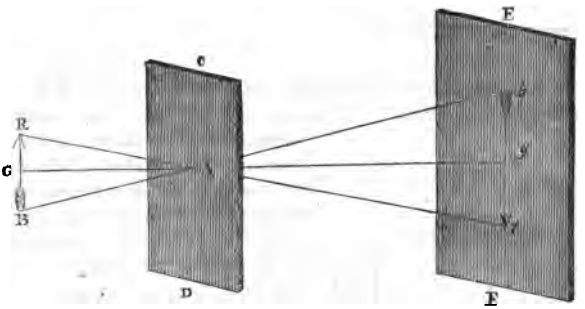


Fig. 33.

a small aperture A, and E F a piece of paper placed in a dark chamber. Then, if an illuminated object, R G B, is placed on the outside of the shutter, we shall observe an inverted image of this object painted on the paper at *r g b*. In order to understand how this takes place, let us suppose the object R G B to have three distinct colours—red at R, green at G, and blue at B; then it is plain that the red light from R will pass in straight lines through the aperture A, and fall upon the paper E F at *r*. In like manner, the green from G, and the blue light from B, will severally fall upon the paper at *g* and *b*, and an inverted image *r g b* of the object R G B will be painted upon it, every coloured point in the object R G B having a coloured point corresponding with it on the piece of paper E F.

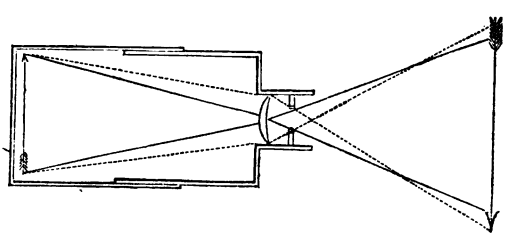


Fig. 34.

If, instead of a darkened room, we substitute a darkened box (Fig. 34), the same effect will be seen. Suppose, in the first place, the box to be without the lens, the rays would pass from the external arrow in nearly right lines through the opening,

refracted only in passing the solid edges of the hole, and form an image on the back of the dark box. The lens refracts the rays, and a smaller but a more perfectly-defined picture is the result. This is the camera obscura.

Although highly appreciated for the magical pictures it produced, this instrument

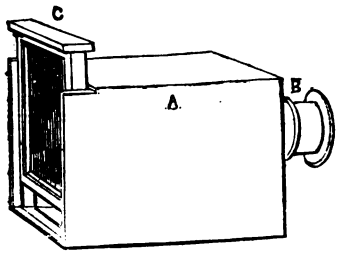


Fig. 35.

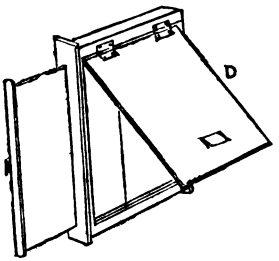


Fig. 36.

remained little more than a scientific toy until the discovery of MM. Daguerre and Niepce developed its powers. It is now so well known as scarcely to require description. The camera is a dark box with doors attached, having a tube for containing the lenses in one of its ends, through which the radiations from external objects pass, and form a diminished and reversed image upon the ground glass at the other extremity. The disposition of the various parts of this apparatus will be understood by reference to Figs. 35 and 36, where A represents the body of the camera; B, the lens; C, the ground glass focusing plate; and D, the dark slide, or back, for holding the prepared plate.

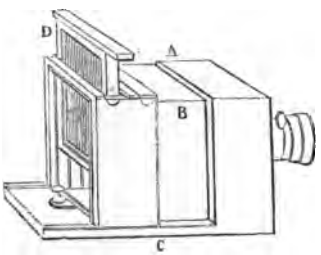


Fig. 37.

There are four grand distinctions in cameras, as to their structure, each being adapted to some peculiar branch of the photographic art; they have been named, from the nature of their configuration, Rigid, Sliding-body, Folding, and Semi-folding. The sliding-body camera will be found of most service in the glass operating room, from the capability it has of admitting a vast range of adjustment, which enables it to be used for almost every purpose. The peculiarities of this form of camera will at once become apparent by referring to Fig. 37, in which A represents the fixed body of the instrument, to which, at the front part, is fixed the lens; B is the second, or inner body, which slides along the board C, fastened to the fixed body; the groove for holding the focusing glass and the dark slide (Fig. 38) is in the hinder part of the sliding box, and is represented by the letter D. There is a slit in the bottom board, in which works the screw and button fastened to the moveable body, which allows of the latter being fixed after its proper position has been determined. From this description, it will be quite evident that a very long range of

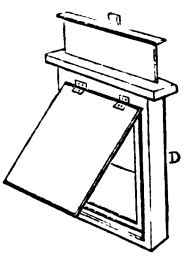


Fig. 38.

focus is obtained by this arrangement; and this will be found of the utmost convenience where we wish to obtain large portraits, or pictures small enough to mount as miniatures in a brooch.

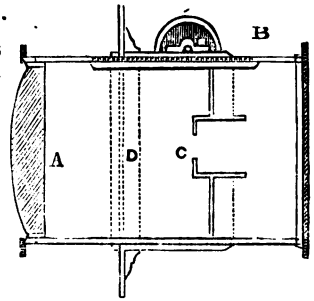


Fig. 39.

The great desideratum in a camera is perfect lenses. They should be achromatic, and the utmost transparency should be obtained; and, under the closest inspection of the glass, not the slightest wavy appearance should present itself, or dark spot be detected; at the same time, a curvature should be secured which prevents, as much as possible, all spherical aberration. The effect produced by this last defect is a convergence of perpendicularity: as, for instance, two towers of any building would be represented as leaning towards each other, or in a portrait the features would seem contracted, distorted, and mingled together, thus throwing the features out of drawing. A variety of moveable diaphragms or caps to cover the front aperture are useful, as the intensity of the light requires to be modified by them, and they should always accompany an instrument. A handy operator can always supply himself with these diaphragms. The engraving (Fig. 39) represents a section of a single lens; A, the lens; B, rack and pinion; C, the stop or diaphragm; D, sections of the camera.

As in the phenomena of vision, so in the camera obscura, the image is produced by the radiations proceeding from the external object; and as these radiations progress from various parts, more or less illuminated, so are the high lights, the middle tints and shadows, most beautifully preserved in the spectral appearance. The colours also, being in the first instance the effect of some physical modification of the primary cause, are repeated under the same influence; and the definition, the colour, and soft gradation of light and shadow, are so perfect, that few more beautiful optical effects can be produced than those presented by the camera obscura.

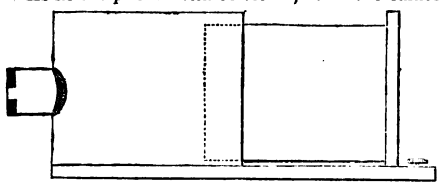


Fig. 40.

By a slight modification of the above simple box, we can form a camera in which we may expose a prepared sensitive plate or sheet of paper to the action of the rays which pass through the lens, the plate or paper being at the same time perfectly protected from the action of any other ray. Some cameras are very simple in construction, merely consisting of a single box, with the lens so mounted or fixed that it can be moved in or out to get the focus, which may be done by means of one tube sliding into another, or of one box having another sliding into it, the lens being fixed as in Fig. 40. The next form is the folding camera, invented

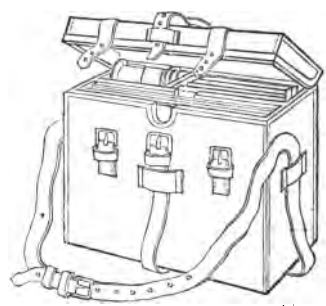


Fig. 41.

by Mr. Ottewill, represented in Figs. 41, 42, and 43. In 41 it is represented packed as a knapsack, in 42 it is fully fixed, and in 43 half open. This is a very portable camera for travelling, and is kept steady and firm by the front board, which holds the lens, sliding into a groove made to hold it.

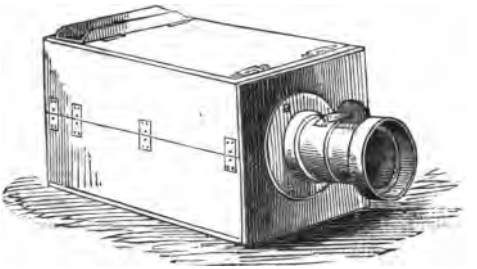


Fig. 42.

I shall next, with the reader's permission, introduce a camera which I invented and made for the late Major Halkett, of the 4th Light Dragoons, who was subsequently killed in the glorious charge at Balaklava. I shall only remark, that to the amateur who practices the paper processes it will prove very portable indeed. The form of this camera is that of a box when closed, in size about 13 inches long, 11 inches deep, and 6 inches wide, with a brass handle on the top by which to carry it (Fig. 44). A camera of the above dimensions will take pictures 11 × 8½ inches.

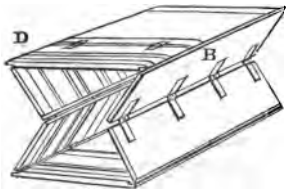


Fig. 43.

Fig. 44.

To shut up the camera, from Fig. 45, you first undo the supports R, which will let down the diaphragm, take out the screws G, G, G, open the air-hole Z, and shut H back into A; put the screws G, G, G in also, and place the two lids, L′ and L″, side by side on the front, and fasten them there by the two hooks V, V; then turn F up against D, and fasten it there by its own hook V. When you get home you take out the pressure-board, and inverting the paper frame, the paper holders will all fall back again out of the box F.

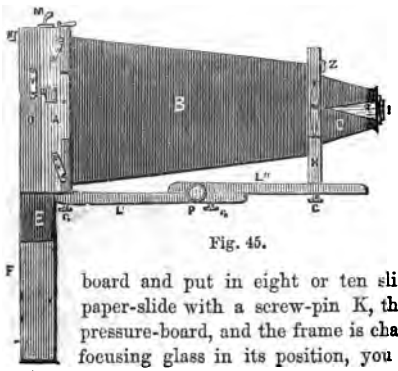


Fig. 45.

When the camera is opened for use, as in Fig. 45, take out the pressure-board and put in eight or ten slides with prepared paper, securing each paper-slide with a screw-pin K, through its eye T; you then replace the pressure-board, and the frame is charged with prepared paper. To place the focusing glass in its position, you lift the frame D about half an inch, and draw it back, when it will separate from A, as shown at Fig. 46, and make room for the focusing glass; having obtained a proper focus, you replace the frame D, pull up the sliding-shutter M, and the first sheet of paper is exposed; you shut down the shutter M, pull back the pressure-board a little, turn the first screw-pin back until you hear the paper-holder drop into the box F; you push in the pressure-board again,

and paper No. 2 is ready to undergo the same process. The first paper-holder may be without an eye, as the pressure-board will keep it in its place until after exposure, and the pressure-board itself can hold another paper on its inside surface, thus increasing the number of pictures which may be taken during one excursion.

Explanation of Figures.—The light tint indicates brass, the middle tint wood, and the dark shading india-rubber material.

Brass. Wood. India-rubber.

Fig. 44. Side view, camera when closed.

Fig. 45. Side view, camera when open. A, frame of camera; B, body of ditto; C, cone also of india-rubber material, extended in front of the lens by three supports R; D, frame for prepared paper, each paper held in a separate holder (S, Fig. 49); E, communication between D and F, made of india-rubber material, through which the prepared paper in its holder passes into F, a box made to receive it after being exposed in the camera;

Back view. Lateral view.
Fig. 46.

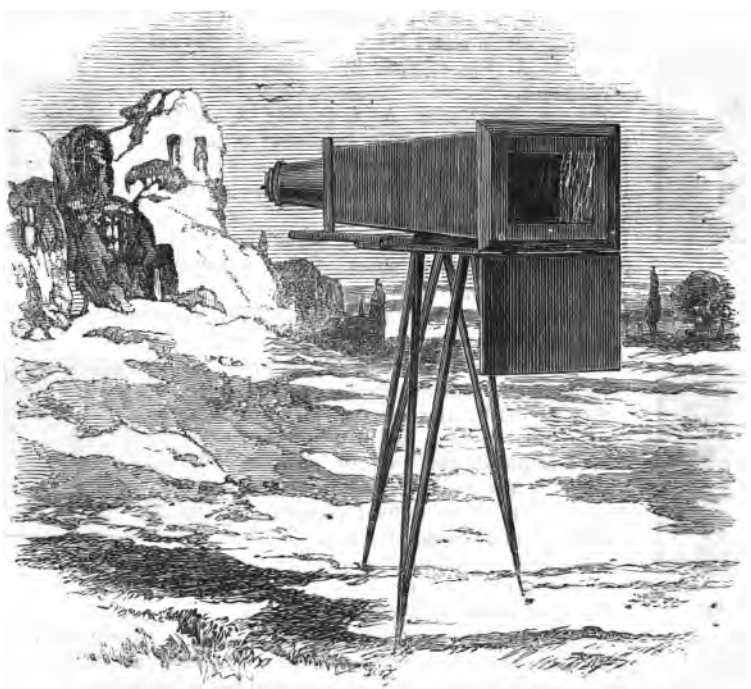


Fig. 47.—Major Halkett's Camera.

G, G, G, nuts and screws used when the camera is open; H, upright frame for front of camera; I, diaphragm in front of lens; K, screw-pins to retain paper in frame until after exposure; L′ and L″, lids of camera; M, shutter in front of prepared paper;

N, lens screwed into W from inside; P, rack and pinion adjustment for focusing; V, V, V, V, hooks and eyes.

Fig. 46. Diagram showing the way in which D is fastened to A.

Fig. 48. Front of camera. I, diaphragm; C, cone; H, frame; W, W, front plate of camera holding the lens; R, R, R, rests to support the diaphragm; Y, Y, plates to retain the front in its frame; X, graduated support to alter the horizontal line; Z, opening to allow passage to the air in opening and shutting the camera.

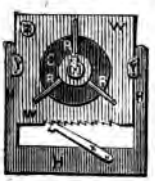


Fig. 48.

Fig. 49. Holder in which the paper is retained, made of mill-board; frame S, S, S, made of veneer, joins S at W, and doubles down on the dotted lines when the paper is in its place; T, an eye through which the screw-pin K passes.

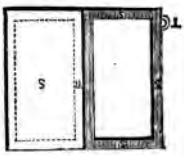


Fig. 49.

Fig. 50. Lid No. 1. A, A, the lid; B, plate by which it is screwed on the stand; C, guiding slit in plate; D*, hole by which that end is screwed to A (Fig. 45); F, F, guiding pins; X, X, focusing rack.

Fig. 50.

Fig. 51. Lid No. 2. A, A, the lid; B, slit for H (Fig. 45); C, C, guiding slits in plates; D, pinion; P, handle to ditto; E, groove for X, X, to work in; F, guiding pin; G, nut for screw in screwing the lids together.

Fig. 51.

Fig. 52. Section of prepared paper frame. D, D, space occupied by paper slides; O, pressure-board to keep the paper against the sliding shutter.

Fig. 53. End view of camera. O, pressure-board; K, K, K, screw-pins to retain the paper until after exposure.

Fig. 52.

In fact, the forms of the camera are innumerable, and it matters little how they are made, provided that they are solid when working, and have a means of substituting the prepared plate or paper for the ground (or focusing) glass, and impervious to all light, except that which passes through the *lens*. When speaking of the collodion process, I intend to mention one or two other cameras, more particularly adapted to that process. A very portable camera is constructed by Vogtlander, the German optician, described as entirely made of brass, so that variations of climate do not affect it, and it occupies a very small space, when packed, even with all the materials for operating. The instrument known as the *copying* camera-box has an extra slide in the back end, by which it may be considerably lengthened at pleasure. We must not omit to mention that of M. Marten, which is known as the Panoramic Camera. The object of this invention is to reproduce, with an objective of medium dimensions, landscapes of great length, analogous to the panoramic feature.

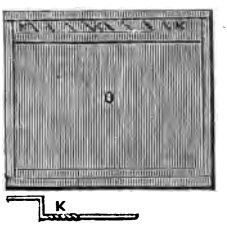


Fig. 53.

Camera Stands.—The best constructed stands are made of maple or walnut wood, having a cast-iron or brass socket for receiving the camera, and having screws for elevating or depressing the instrument (Fig. 54).

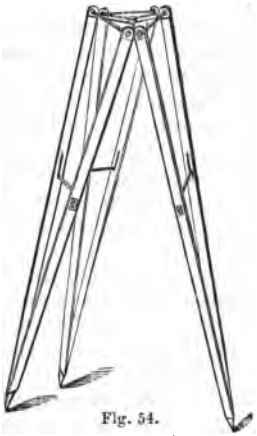


Fig. 54.

I shall next present my readers with a drawing of a dark frame for two pieces of paper and a glass, against which paper is pressed with a sheet of blotting-paper between. B B (Fig. 55), clips to fasten the frame when shut; *a a*, the slides or shutters.

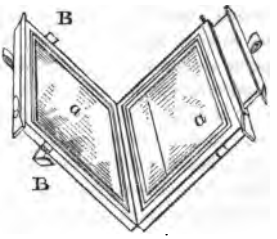


Fig. 55.

Figs. 56 and 57 represent two useful articles, viz., the nitrate bath and dipper, and the board and rod for spreading solutions on paper. This consists of a piece of wood covered with soft flannel or blotting paper, on which the paper is laid, and B a glass rod, by means of which the solution is spread evenly over the surface of the paper.

Fig. 56.

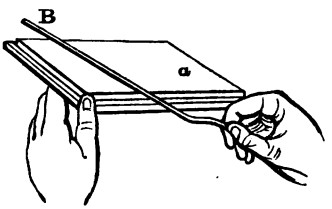


Fig. 57.

Our next figures represent as follows: — Fig. 58, a precipitating glass used for the purpose of making double iodide of silver. Fig. 59, glass rods for spreading solutions on the paper; and Fig. 60, nippers for lifting paper out of the various solutions; while Figs. 61 and 62 represent a graduated measure glass and a cup for pouring out the several liquids into their respective bottles.

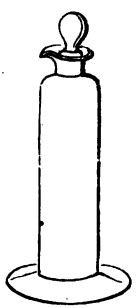


Fig. 58.

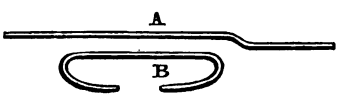


Fig. 59.

Fig. 60.

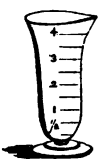


Fig. 61.

Fig. 62.

THE CALOTYPE PROCESS.

We have seen that the first person who discovered the preparation of a photographic paper, possessing such exquisite sensitiveness that it might be impressed with the image of a natural object in a minute or less in the camera, was Mr. Fox Talbot. He called this the calotype process; but some photographers, out of compliment to the discoverer, have since called it Talbotype, as the Daguerreotype is so called after Daguerre, who was the first to discover the properties of the process so named. M. Biot, a French chemist of great authority, who seems to have paid considerable attention to the subject, was called upon to report to the Académie des Sciences on the results of the new process. In his report he proceeds to say, after paying some attention to the Daguerreotype process:—

"It is scarcely expected that photogenic drawings, produced on paper, can at first equal the clearness and fineness of those obtained on level and polished metallic plates, because the texture of the paper, the roughness of its surface, the irregularity of its imbibitions, and the capillary communication established between the various unequally-marked parts of its surface, are so many obstacles to absolute strictness of delineation, as well as to the regular gradation of tints in the camera obscura; and the influence of these obstacles is greater when the chemical operation is slowly carried on. But where there is no pretence or necessity for submitting to the delicacies of art—when it is merely required, for example, to copy rare manuscripts faithfully—if we have papers which are very susceptible of receiving impressions in the camera obscura, they will suffice perfectly; particularly when they present, like those of Mr. Talbot, the facility of immediately procuring copies of the primitive drawing. It will, indeed, be found more commodious, and much more practicable, to put four or five hundred drawings in a portfolio, than to carry about a smaller provision of metallic plates with those indispensable squares of glass to protect them. Attempts are being made, at this time, to fix the images produced by the Daguerreotype—perfect prints, it is true, but which are as light as the vapour from which they are produced; and, indeed, to bring a voluminous collection of these fragile products through the accidents incident to long, and sometimes perilous voyages, is a task requiring no ordinary care. But whoever has attentively studied the combination of physical conditions whence these beautiful images result, will find it very difficult—I should not like to say impossible—to fix them without destroying, or at least without essentially altering, the causes which produce their charm; for the purposes, then, which I have mentioned, papers very susceptible of impression would still have the advantage of being less troublesome in removal from place to place, and much more easily preserved.

"Early in 1830, drawings on paper were handed about in the scientific circles of London and Paris, which were a great advance upon anything that had been previously done. These were the results of a new process discovered by Mr. Fox Talbot; but for several years after his process was made public, little or no progress was made in the art; and it is no injustice to Mr. Talbot to ascribe this interruption to the circumstance of that gentleman having protected his discovery by a patent. It is gratifying to be able to announce that Mr. Talbot has since made the country a free gift of his patents.

"The utility of sensitive papers for copying inscriptions was a natural consequence of the clearness of the copies of engravings which Mr. Talbot had already presented to

the Academy. He has included, amongst others just sent, specimens of this special application of the art, which are copies of a Hebrew psalm, of a Persian gazette, and of an old Latin chart of the year 1279. Our brethren of the Académie des Belles Lettres, to whom I exhibited these impressions, were pleased to remark the fidelity of the characters, and their clearness, for they are rendered as legible as the original text. By this process, an old manuscript may be copied more quickly, and much more accurately, than by hand, even when the language in which it is written is understood.

"But this important extension will require much physical perfecting, towards which experimenters should direct their efforts. The first thing will be to increase the sensibility of the paper as much as possible, in order that the capillary communication of its various parts may not have sufficient time to deteriorate the effects of the local and immediate action of the light. I should be led to believe that to this kind of communication is principally to be attributed the fact remarked by Mr. Talbot, that, in experiments by application, it is more difficult to copy clearly a tissue of black lace spread on a white ground, than white lace on a black ground. But another more general and more hidden difficulty seems to me to proceed from the unequal faculty of various substances for reflecting the radiations which strike them, and perhaps from their aptitude for making them undergo physical modifications. For example, you wish to copy by radiation in the camera obscura a picture painted on canvas, wood, or porcelain: the different colouring substances employed by the painter are placed and distributed in such a manner that each of them absorbs certain portions of the total incidental light, and reflects especially towards your eye the complementary portions, wherein predominate the rays proper to form the tint of which it would give you the sensation. But the chemically active re-agent which the same parts of the picture receive and reflect is distinct from the light which affects your retina. In order that the chemical effect which it produces on the sensible paper, or on M. Daguerre's layer of iodine, may present, in light or in shade, the equivalent of the coloured parts, it is requisite—1st, that this reflected radiation be chemically active; 2nd, that the energy of its action be proportional to the intensity of illumination operated in the eye by the portion of luminous radiation reflected from the same point of the picture. Now this latter concordance certainly should not be fulfilled in an equal degree by the various colouring matters, which affect the eye in the same manner, and which the painter may substitute for one another in his work. Substances of the same tint may present, in the quantity or the nature of the invisible radiations which they reflect, as many diversities or diversities of the same order as substances of a different tint present relative to light; inversely they may be similar in their property of reflecting chemical radiations when they are dissimilar to the eye; so that the differences of tint which they presented in the picture made for the eye will disappear in the chemical picture, and will be confused in it in a shade, or of an uniform whiteness. These are the difficulties generally inherent in the formation of chemical pictures; and they show, I think, the illusion of the experimenters who hope to reconcile, not only the intensity, but the tints of the chemical impressions produced by radiations, with the colours of the objects from which these radiations emanate. However, the distant or near relations of these two species of phenomena are very curious to study, not only as regards the photogenic art, but likewise as regards experimental physics. I doubt not that examples of these peculiarities may be remarked in the images of natural objects and coloured pictures executed by the Daguerreotype; but very apparent ones

may be seen among Mr. Talbot's present impressions. Thus, some of them represent white porcelain vases, coloured shells, a candlestick (of metal) with its taper, a stand of white hyacinths. The whole of these objects are felt and perceived very well in their chemical image; but the parts which reflect the purely white light, probably also the radiations of every kind, are, relatively to the others, in an exaggerated proportion of illumination, which, it seems to me, must result partially from the capillary communication during the continuance of the action; so that the inequality would be less if the paper were more sensitive or more rapidly acted on. In the hyacinth, the stalk and the green leaves have produced scarcely a faint trace of their configuration; but they are strongly defined, especially in the parts of the outline, where more or less perfect specular reflection takes place. The points of the candlestick (metallic) where this reflection occurred are copied by white stains locally applied, and which deteriorate the effect of the whole by their disproportion. But this is seen especially in a picture by Correggio, the frame of which was very vividly copied, whilst the figure on the canvas was hardly perceptible. This disproportion of lustre in the reproduction of some white parts, especially when they are dull and consequently very radiating, is sensible in certain parts of views taken by Mr. Talbot, to the point of rendering difficult the interpretation of the object to which they belong. However, these views are very satisfactory, as being obtained on paper, in the present season. Moreover, by an advantage peculiar to the chemical preparation which Mr. Talbot uses, it appears that the operations once completed, the drawings are no longer alterable by radiation, even acting with much energy.

"Indeed, we have here, as an example, four proofs of the same view of Mr. Talbot's house, with an identical disposition of lights and shades; so that some, at least, if not three out of four, must have been procured by superposition. Mr. Talbot is right in representing this property of reproduction as an especial advantage of his process, and it would indeed be very useful in voyages. I have exposed one of these drawings to the action of the sun—not very powerful, it is true—for several hours, and I have not perceived the slightest alteration in the lights. I think I understand that, in Mr. Talbot's opinion, the shades alone are strengthened under this influence. According to what I have just said, it should be expected that the triumph of this process, as of every other photogenic reproduction, would take place with objects of white and dull plaster. Indeed, Mr. Talbot's parcel contains eight copies of busts and statues; six of which chiefly, of various forms and sizes, present very remarkable results, especially taking into consideration the unfavourable season at which they were produced. There is not found in them the strict perfection of trace, nor the admirable gradations of lights and shades, which constitute the charm of M. Daguerre's impressions. But representations on sensitive papers must be considered as principally applicable to a different object, which does not impose such strict conditions of art, requiring only faithful images, sufficiently clear in their details to be readily recognised, and which, moreover, being obtained with rapidity, by an easy manipulation, may be kept with very little care, comprised in great number in a small compass, and moved from place to place with facility. Mr. Talbot's papers already present many of these essential qualities, with the advantage of being able to furnish numerous copies immediately. His efforts, and those of others occupied with the same subject, will conclude by adding to them everything which may be desirable, provided that expectation, or the pretension of a perfection of art physically incompatible with operations on paper, do not give a false direction to their endeavours. However, I may here add, that the height

of success would consist in discovering a substance very susceptible of receiving impressions, which might be applied on a papyraceous leaf without penetrating deep into it, and which might, however, be fixed in it after the operation, as in Mr. Talbot's impressions. It does not seem necessary even that the first impression thus rapidly obtained should copy the lights and shades in their proper places, provided that its transparency and fixedness were such, that we might deduce them from the application of copies wherein the inversion would be corrected. And perhaps, by this decomposition of the problem into two successive operations, one of the best ways is opened by which it may be resolved."

"But so much improvement has taken place in the manufacture of paper for the purpose, as well as in the manipulation, that many of the early obstacles have been overcome; and photographs on paper, as may be seen at the present year's exhibition of the Photographic Society, have attained a degree of excellence not anticipated by the French savant. Paper has, moreover, qualities of its own for the purpose; it wants the glitter arising from the polished surface of the metal plate, so that its beauties can always be seen."

The Talbotype Process has been largely improved upon by Mr. Cundall and others; but it may be interesting to my readers to have the process described as practised by the inventor; adding, however, as I proceed, some of the more important improvements upon his formulæ.

The apparatus required are, two or three square shallow porcelain dishes, an ample supply of distilled water, a glass graduated measure and funnel (Fig. 63), a supply of blotting-paper, large flat and soft hair pencils, and a supply of the best writing paper of medium thickness, perfectly smooth surface, transparent, compact, and uniform in texture, and without speck, water mark, or maker's name. Also a supply of the following solutions, viz.:—

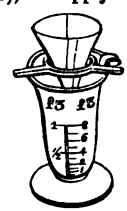


Fig. 63.

No. 1. A solution of 100 grains of nitrate of silver, dissolved in six ounces of distilled water.

No 2. A solution of 500 grains of the iodide of potassium in one pint of distilled water. (Mr. Cundall uses 400 grains iodide of potassium, and 100 grains of common salt, as an improvement analogous to that of M. Claudet in the Daguerreotype process.)

No. 3. A solution of 100 grains of nitrate of silver in two ounces of cold distilled water, adding to it a sixth part of its quantity of concentrated acetic acid.

No. 4. A solution of crystallized gallic acid, saturated in distilled water. (This should be prepared in small quantities, as it will only keep for a few days.)

No. 5. A solution of 100 grains bromide of potassium in eight or ten ounces of distilled water.

Having selected suitable paper, and cut it to the proper size, which should be at least an inch each way larger than the object to be represented, mark one of the corners with a pencil, so that the side on which the preparation is laid may be known, pin the paper by two of its corners to a board, and by means of a soft brush apply the preparation No. 1 carefully and smoothly to the surface of the paper, taking care to wash it thoroughly over without any mark of the brush, and that the solution is thoroughly absorbed. The paper may be suffered to dry by hanging from the board in the air, but without exposure to light.

When thoroughly dry it is ready for the next operation, which consists in pouring a portion of the second solution, just sufficient to cover the surface, into a shallow

porcelain dish, which should be large enough to receive the paper. As only the prepared side of the paper should receive this solution, fold a narrow upright margin all round the paper, turning in the corners, holding it by two corners; let the side to which the previous solution has been applied, be drawn gently and smoothly over the surface of the solution, resting on it till it is thoroughly saturated. In this state it may remain for a few seconds, but not more than a minute, otherwise the nitrate solution may be decomposed by the iodine liquid.

The paper, now thoroughly saturated with the iodized liquid, is hung up in a proper place until about half dry. The paper is now thoroughly imbued with the preparation, and the nitrate of silver thoroughly decomposed; but it is now necessary to remove every trace of the salts with which the paper has been saturated. This Mr. Cundall accomplishes by floating the paper with its upturned margin on a basin of pure water for eight or ten minutes, drawing it occasionally gently along the surface to remove the soluble salts, which will separate from their own gravity; while the iodide of silver, being insoluble in water, remains upon the paper, presenting the surface required for a successful operation.

The paper should now be left to dry spontaneously, without being touched or the surface disturbed. When dry, it may be subjected to sufficient pressure to smooth it. In order to preserve its sensibility, it should be carefully secluded from the light, and placed in a portfolio. The paper thus prepared is called iodized paper ready for use.

For the third operation Mr. Talbot made use of the solutions 3 and 4 in the following manner:—Mix equal parts of the two solutions by means of the graduated drachm tube, but only in quantities required for immediate use, as it quickly loses its quality; Gallo-nitrate of silver is obtained by this means. With this mixture the iodized paper is washed over by means of another soft brush, using increased care in laying it on, so as to secure a smooth and even surface and equal distribution. Leave the solution to settle for eight or ten seconds, then dip the surface in pure water, still holding it by its upraised corners, and drawing the paper gently over the water several times; it is again drawn through a second course of fresh water two or three times. After being dried in the dark and at a distance from the fire, it is fit for use, and may be placed in the camera while the surface is dry, but still moist, or it may be placed in a portfolio with blotting-paper for future use. Mr. Cundall, and other recent operators, find it necessary to apply the gallo-nitrate as follows:—Pour out the solution upon a clean slab of glass, diffusing it over the surface to a size corresponding with that of the paper. Holding the paper by the narrow upturned margin, the sensitive side is applied to the liquid upon the slab, and brought in contact; so that by passing the fingers gently over the back of the paper, the surface is thoroughly wetted with the gallo-nitrate. Mr. Cundall further recommends, that in all cases when extreme sensitiveness is not required, the liquid should be diluted to one-half the strength indicated above, otherwise the paper is apt to be stained or embronzed, unless the manipulation be extremely well-managed. Rain, river, or spring water answers perfectly to *wash* the papers, distilled water being required for the silver solutions only.

These operations Mr. Talbot recommends should be performed with as little light as possible, and that should be candle light.

And now the paper is ready to place in the camera, where the operator is to use his own judgment in forming his pictures, and his experience in getting proper effect. According to the intensity of light and colour of the object, is the length of exposure, which may vary from five seconds to two minutes.

When the operation is terminated, it is necessary to develop the image by washing the surface over with a brush charged with the gallo-nitrate of silver, exposing it at the same time to a gentle heat from a hot iron or other similar body, held at the distance of an inch or two, the iron being held vertically, and the paper moved backwards and forwards so that it may all dry simultaneously. In the course of a few seconds the picture will become visible, usually of a fine blackish-brown colour.

When sufficiently developed, it is necessary to wash it immediately in pure water to remove the gallo-nitrate of silver. This last process of washing should be done before the paper has become quite dry, and, if necessary, the drying should be retarded by the application of hot vapour or a jet of steam. The final process is fixing the image.

This was accomplished by Mr. Talbot by dipping it first in water, and, after drying, washing it over with a solution of bromide of potassium. (Solution No. 5.) And, after a last washing in water, it is finally dried. A strong solution of common salt was substituted for the bromide of potassium, but was not so successful.

The present practice, as described by Mr. Cundall, is as follows :—In order to remove the sensitive matter from the picture, it is to be soaked, he says, "in warm water, but not warmer than may be borne by the finger. This water is to be changed twice, and the pictures are then to be well drained or dried in clean and dry blotting-paper, to prepare them to imbibe a solution of the hyposulphate of soda, which is prepared by dissolving an ounce of that salt in a quart (forty ounces) of water. Having poured a little of the solution into a flat dish, the picture is to be introduced into it; daylight will not now injure them. Let them soak for two or three minutes, or even longer, if they are strongly printed, turning them occasionally. The remaining unreduced salts of silver are thus thoroughly dissolved, and may now, with the hyposulphate, be entirely removed by soaking in water and pressing alternately in clean blotting-paper; but if time can be allowed, soaking in water alone will have the desired effect.

The impression now obtained is a negative, that is, the parts of the object which is white in nature are here represented black, and *vice versa*. From this impression, however, any number may be taken, having the lights and shadows as in nature. This is performed by placing upon the negative a piece of properly-prepared photographic paper, and in immediate contact with it, having previously rendered it as transparent as possible. By exposure to the light, the second impression is formed. The progress of the impression may be watched by raising one of the corners of the negative from time to time. The mode of rendering the negative transparent, as adopted by Mr. Fox Talbot, was as follows :—Grate some virgin wax on the back of the paper, and, having placed it between two pieces of white paper, draw a hot iron gently over it until the dissolved wax has throughly penetrated the paper of the negative, and rendered it somewhat transparent.

When many impressions are taken, the original loses a portion of its vigour, which may, however, be restored by dipping it again in the gallo-nitrate of silver, washing it in hot water, and fixing it as before directed. These impressions may be obtained by using calotype paper, but Mr. Talbot recommends photogenic paper prepared as follows :—

Having dissolved 25 grains of common salt in one ounce of distilled water, dip the paper selected and cut to a proper size in this liquid, leaf by leaf, leaving it there to soak for a short time, and place it between leaves of clean blotting-paper to dry; dissolve afterwards 90 grains of crystallized nitrate of silver in an ounce of distilled

water, wash the paper on the seen silver side, with a soft pencil charged with this liquid, dry it a little, and pass another coating of the liquid over it, dry it thoroughly, suspending it for that purpose by one of the corners.

A more simple preparation of photographic paper is produced by dissolving 100 grains of bromide of potassium in an ounce of distilled water; dip the paper in this solution, place it as before between the leaves of blotting-paper, and when nearly dry wash the sensitive side with a solution of 100 grains nitrate of silver, dissolved in an ounce of distilled water; dry the paper in a darkened place, and, if required to be very sensitive, apply a second wash of the solution. This paper has presented the best results.

The impression obtained upon these papers in the manner described, form the calotype process. Their sensibility is such, that images of feathers, leaves, and other similar objects, are said to be obtained by the light of a jet of gas while still moist; holding the paper four or five inches from the flame, the impression will appear in three or four minutes.

The precautions to be taken during the preceding operations are as follow:—

1. It is necessary to have a clean brush for every solution, and to wash them carefully every time they are used. The brush used for the gallo-nitrate of silver is quickly destroyed.

2. The same blotting-paper should never be used but for the same solution, and it is better to have separate blotting-books prepared, with the names of the solution written on each.

3. The distilled and other waters should be changed with every operation.

4. Dr. Ryan observed that if the paper remained too long in the solution No. 2 (iodide of potassium), the iodide of silver was formed. He recommends, therefore, that the leaf should be dipped and removed promptly to prevent this formation.

5. Mr. Mitchell modifies the process in the following particulars:—He first applies the solution No. 2 (iodide of potassium), drys it; then the solution No. 1 (nitrate of silver), drys that also; and having dipped the paper for one moment in a solution of 125 grains of iodine, in an ounce of water, washes it in distilled water, and finally drys it. By this means Mr. Mitchell obtains a paper more sensitive, and, as is said, with the substances more equally distributed than by Mr. Talbot's process.

Improved Talbotype Process.—Many improvements have taken place in the Talbotype process. Mr. Talbot has himself introduced the following:—In order to get rid of the yellow tint in images taken on paper prepared with a solution of nitrate of silver, he proposes to plunge the paper after it is impressed into a hot bath, composed of hypo-sulphate of soda or other hypo-sulphate dissolved in ten times its weight of water, heated to ebullition. The paper should remain about ten minutes in this bath, then be washed in cold water, and dried. By this means it is rendered both more permanent and more transparent; the lights are brought out better. The transparency of the paper can still be increased after this operation by the application of wax as already directed.

Another improvement consists in placing a hot iron plate behind the darkened frame, which covers the paper while it takes the image in the camera, thus communicating heat to the paper, and rendering it more sensitive.

I have been induced to give the formulæ of these different photographic authors, so that if the reader cannot arrive at a satisfactory result by one process, he may try another. And here I may as well remark, that the amateur should not be led too

easily to try all the different processes he may hear or read of, for acquirement of a perfect knowledge of one of them is quite enough for a lifetime.

I am now about to introduce the reader to two photographers who have distinguished themselves by their successful practice in this process. I need scarcely say that the two gentlemen I speak of are Sir William J. Newton, and J. D. Llewellyn, Esq.

Sir W. J. Newton's Process.—This gentleman has taken great interest in the art, and has materially contributed to its advancement by his own manipulation. I cannot, therefore, do better than give his formula in his own words, copied from the Journal of the London Photographic Society, to the writers of which I feel exceedingly indebted for much valuable information.

"*To Iodize the Paper.*—1st, Brush your paper over with muriate of barytes (half an ounce, dissolved in nearly a wine-bottle of distilled water); lay it flat to dry. 2nd, Dissolve sixty grains of nitrate of silver, in about an ounce of distilled water. Ditto sixty grains of iodide of potassium in another bottle with the like quantity of water. Mix them together and shake well; let it subside; pour off the water, and then add *hot* water; shake it well; let it subside; pour off the water again, and add three ounces of distilled water, and afterwards as much iodide of potassium as will redissolve the iodide of silver.

"Brush your previously-prepared paper well with this, and let dry; then place them in water, one by one, for about one hour and a-half or two hours, constantly agitating the water. As many as a dozen pieces may be put into the same water, one after the other, taking care that there are no air-bubbles; take them out, and pin to the edge of a board at one corner. When dry they will be ready for exciting for the camera by the following process:—

(These are supposed to be in six 1-ounce bottles with glass stoppers.)

1.	2.	3.
1 drachm of No. 4, 6 drachms of distilled water.	20 min. of No. 3, 6 drachms of distilled water.	A saturated solution of gallic acid.

4.	5.	6.
25 grains of nitrate of silver to half an ounce of water. Add 45 minims of glacial acetic acid.	2 drachms of No. 4, 6 drs. of water.	Equal parts of Nos. 1 and 2. N.B.—This must be mixed just before using, and the bottle cleaned afterwards.

"*To Excite for the Camera.*—Mix equal parts of Nos. 1 and 2, and with a glass rod excite the iodized paper and blot off; and it may be put in the slide at once, or the number you require may be excited, and put into a blotting-paper book, one between each leaf, and allowed to remain until required to be placed in the slide.

"*Time of Exposure.*—The time varies from three minutes to a quarter of an hour,

according to the nature of the subject and the power of the sun; but five minutes is *generally* the proper time.

"*To Bring Out.*—Bring out with No. 3, and when the subject begins to appear, add No. 5; and when sufficiently developed, hold it up, and pour water upon it; then put it into hyposulphite of soda to fix it, for about an hour or more, and then into water; this is merely to fix it for the after process, at your leisure.

"*To Clean the Negative.*—Get a zinc tray about three or four inches deep, with another tray to fit in at the top, about one inch deep; fill the lower tray with boiling water, so that the upper tray may touch the water; put your solution of hyposulphite of soda, not strong, in the upper tray, and then your negatives one by one, watching them with care until the iodine is removed; then put them in hot water, containing a small piece of common soda (the size of a nutmeg to about two quarts of water), for about ten minutes; pour off the dirty water, and then add more hot water, shaking them gently for a short time; pour off the water again, and then add fresh hot water, and let it remain until it is cold, after which take them out carefully one by one, and put them in clean cold water for an hour or two; then take them all out together, and hold up to drain for a short time, and then put them between three or four thicknesses of linen, and press as much of the water out as you can; then carefully (for now all the size is removed) lay them out flat separately upon linen to dry.

"*Mode of Waxing the Negatives.*—Melt the pure white wax over a lamp of moderate heat, just merely to keep it in a liquid state; then fill the same deep tray as above described with boiling water, and with another similar to the upper one before described (which must be kept for this purpose only); put a clean piece of blotting-paper in this tray, and lay your negative face downwards, and with a soft flat hog's-hair brush, about an inch wide, dip it into the liquid wax, and brush the negative over, when it will be immediately transparent, and it can be done so that there is very little redundant wax; after which it may be put between two or three thicknesses of blotting-paper and ironed if necessary, which, however, should not be very hot, when it is ready to take positives from.

"*Positives on Negative Paper.*—Take one part of the iodide of silver before described, and add two parts of water; then add as much iodide of potassium as will redissolve it. Brush your paper with the foregoing, let dry, put into water, and procced, in all respects, as above described for the negatives.

"*Excite for Positives.*—Excite with No. 1; blot off; lay it in your press, place the negative face downwards; expose to the light from ten seconds to half a minute, or more, according to the light (not in the sun), and bring out with No. 3; and when it is nearly developed add No. 1; then take it up and pour water upon it, and then place it in hyposulphite of soda (cold) until the iodine is removed; after which put it into alum water, about half a teaspoonful of powdered alum in two quarts of water; this will readily remove the hyposulphite, and also fix the positive more particularly; it will also take away any impurities which there may be in the paper; after which put it into clean cold water, and change two or three times.

"I have been thus particular in describing the process which I have adopted, more especially for beginners; and with great cleanliness and care in each process, and especially in keeping all the bottles with the chemicals free from dirt of every kind, the foregoing will lead to favourable results."

Mr. Llewellen's Process.—This gentleman, after stating that his method of manipulating is almost similar to Mr. Fox Talbot's process, says:—

"I have carefully followed the steps of its progress, and have, I believe, tried nearly all the modifications which have been at various times suggested, and it is remarkable that, in the long period which has now elapsed, no important improvements in paper photography should have been introduced.

"The paper which I use is manufactured by Turner, of Chafford Mills, and bears the water-mark of 'Turner's Patent Talbotype.' It is not free from faults; black specks, arising from brass and iron used in its manufacture, will often appear, but it is a firm compact texture, and makes good negatives, free from the woolliness which is fatal to other samples of paper which in other respects are superior.

"A sheet of this paper should be fastened with silver pins to a piece of flannel stretched over a board, and liberally brushed on one side with a solution of nitrate of silver, of the strength of thirty-three grains to the ounce of distilled water.

"In doing this, and in the subsequent manipulations, I use a brush formed of a flock of cotton wool, partly drawn through a glass tube, which thus makes a convenient handle; this arrangement was suggested by Mr. Buckle, and I believe, bears his name; it is known as a Buckle brush, and in my experience possesses advantages over a glass rod or triangle, or any of the other many contrivances which have been suggested, for the convenience of spreading solutions.

"As soon as the sheet of paper is partially, but before it is quite dry, say in about two minutes, it is to be immersed in a bath of iodide of potassium, of the strength of twenty grains to the ounce of water; all air-bubbles must be carefully got rid of; and the sheet will speedily assume a primrose-yellow colour, the back appearing nearly as bright as the face.

"It may now be shifted at once to a bath of water, which should be changed four or five times, and the paper allowed to soak in it for two or three hours, so as to insure the removal of all soluble salts, and leave a pure iodide of silver distributed throughout the substance of the paper.

"The whole of the process may be performed in full daylight.

"When thoroughly washed, each sheet is to be hung up separately, and when dry is improved by exposure for an hour or two to the full rays of the sun.

"It may then be subjected to strong pressure in a screw frame and kept for use; it will keep good for any length of time.

"To excite it for camera use, take three drops of aceto-nitrate of silver (*the aceto-nitrate consisting of fifty grains nitrate of silver with one ounce of water and one and a half drachm of acetic acid*), and three drops of a saturated solution of gallic acid; add these to one drachm of distilled water, which quantity will be about sufficient for a sheet of the ordinary size of 9 × 7 inches.

"In summer weather the above proportions are sufficient, but in winter, when the air is cold, four or five drops of aceto-nitrate, and four or five of gallic acid may be safely used to the drachm of water.

"This exciting solution should be liberally applied, in the same manner as that described for iodizing; the paper should be evenly and thoroughly wetted, and when well soaked, blotted off with a sheet of clean white blotting-paper. A round ruler rolled over it with a firm pressure, answers very well, and insures a uniform application.

"The paper is now ready for the camera, and should be screwed firmly into the holder, so as to exclude all air as much as possible. Under these circumstances it will keep damp for many hours, and may be depended upon to retain its whiteness, even in summer weather, for twelve hours.

"With a three-inch Ross lens, and a quarter-inch diaphragm, the time of exposure will vary from eight to fifteen minutes, according to the character of the light and the colour of the object to be copied. The exact time can only be taught by experience.

"In developing I make use of aceto-nitrate of silver, and solution of gallic acid in equal proportions, the same as directed for the exciting compound, but without the addition of any water. This must be mixed only immediately before it is wanted, as it decomposes with great rapidity; having prepared a sufficient quantity for a single sheet, say about one and a-half drachm, brush it over the excited side of the paper with a clean new brush.

"The picture ought now gradually and evenly to appear, beginning with the sky, and then faintly exhibiting traces of the darker parts and the shadows. At this point of the development I abandon the use of the compound mixture, and continue the action with the gallic acid alone. A Buckle brush (Fig. 63) is here of great service, as it enables the operator to add more of nitrate of silver, or more of gallic acid, as the case may require, to the different portions of the picture; and this is a very proper place to describe that article. A Buckle brush, then, is made as follows:—Procure a piece of glass tube, B, about half an inch in diameter and six inches long; have either a piece of silver wire, A, a little longer than the tube, and with a loop at one end, or a piece of silk thread, pass the wire or thread through the tube, and fasten to the end which comes through a tuft of clean cotton wool, C; by pulling the other end of the wire, it forms a very nice sort of brush for spreading solutions; the wool can be thrown away when dirty, and a fresh piece substituted; the loose end of the wire may be held in its place by bending it over the edge of the tube.

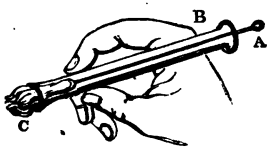


Fig. 63.

"In those parts where it develops too slowly, nitrate of silver may be chiefly used, while, on the other hand, the parts which are inclined to darken too quickly, may be brushed with the solution of gallic acid alone; and thus a more complete control over the development of the picture is obtained than can be effected by the use of the glass rod, or any other method that I am acquainted with.

"By this practice I have saved many pictures that must otherwise have been lost, and in many others again, have obtained a higher degree of excellence than would have been practicable under other treatment.

"In order to obtain a negative that will print well, it is better to carry the development further than may at first sight appear desirable, and it should be carefully examined by transmitted light before the operator is satisfied. When a full definition, even in the parts where the shadows of the landscape were the darkest, has been obtained, the photograph should, without delay, be well washed in cold water, and then immersed in a saturated solution of hyposulphite of soda, and left in this until all trace of the yellow iodide of silver has been removed.

"If this should prove tedious and difficult, as will sometimes be the case, it is well to pour away the solution into a stock bottle, and make a little fresh (*just enough* to cover *the sheet*), which will always, on application to the half-cleared picture, complete the removal of the yellow colour; and the new solution may be added to the stock bottle, and thus aid in keeping up its strength.

"The proof must now be thoroughly washed for an hour or more, in several

waters, to get rid of all trace of hyposulphite of soda, which, if suffered to remain, would gradually destroy the picture.

"When thoroughly dried, it should be waxed, which may be done without risk, by laying the sheet between two pieces of blotting-paper saturated with ordinary white wax, and passing a moderately hot box-iron over the whole. A sufficient quantity of wax will be absorbed by the photographic negative, which will thus become transparent when viewed by transmitted light.

"It will print much quicker, and is less liable to injury from any chance contact with liquid, or from the humidity of the air, than if left unwaxed.

"The photograph is now finished.

"In the foregoing description I have descended into particulars which will, I fear, seem tediously minute, to those who are not aware how much, in photography, depends upon trifles. But I am convinced that the difference between the works of different operators mainly consists in the observance or the neglect of trifles seemingly altogether unimportant. Other formulæ besides those which I describe will, I well know, produce excellent results in the hands of skilful manipulators. I only speak of those methods which for some time past I have myself exclusively used, and by aid of which I have succeeded in making my best negatives.

"The practice is simple and certain, and I recommend it with confidence."

M. Le Gray's Process.—Among the many modifications of the calotype, we have that of M. Gustave Le Gray, who gives us the following directions:—

"*First Operation.*—Dissolve three hundred grains of isinglass in one pint and three quarters of distilled water (for this purpose use a water bath).

"Take one-half of this preparation while warm, and add to it as under.—

Iodide of Potassium	200 grains
Bromide of ditto	60 „
Chloride of Sodium	34 „

Let these salts be well dissolved, then filter the solution through a piece of linen, put it, still warm, in a large dish, and plunge in your paper completely, leaf by leaf, one on the other, taking care to prevent the air-bubbles from adhering to the paper.

"Put about twenty leaves at a time into the dish, then turn the whole, those at the top to the bottom, then take them out one by one, and hang them by one corner with a pin bent like the letter S, to dry spontaneously.

"When hung up, attach to the opposite corner a piece of bibulous paper, which will facilitate the drying.

"When the paper is dry cut it the size required, and preserve it in a folio for use; this paper may be made in the daytime, as it is not sensitive to light in this state.

"The bromide does not, in this case, act as an accelerator, as it does on the silver plates of the Daguerreotype, because, instead of quickening, it retards the operation a little; its action is to preserve from the gallic acid the white of the paper, which would blacken more rapidly if you employed the iodide of potassium alone.

"*Second Operation.*—Prepare, by the light of a taper, the following solution in a stoppered bottle—distilled water, six fluid ounces; crystallized nitrate of silver, 250 grains.

"When the nitrate is dissolved, add one ounce of crystallizable acetic acid; be careful to exclude this bottle from the light, by covering it with black paper. This solution will keep good until the whole is used.

"When you wish to operate, pour the solution upon a porcelain or glass slab, surrounded with a glass or paper border to keep the liquid from running off. I usually take the solution out of the bottle by means of a pipette, so as to prevent the distribution of any pellicle of dust or other impurity over the glass slab.

"Take a sheet of the iodized paper by two of the corners, holding them perpendicularly, and gently lower the middle of the paper upon the centre of the slab; gradually depress until the sheet is equally spread; repeat this operation several times until the air-bubbles disappear; take also the precaution to keep the upper side of the paper dry.

"In order to prevent the fingers from spotting the paper, pass a bone paper-knife under the corner of the sheet, to lift it from the slab between that and the thumb.

"Let the sheet remain upon the slab until the formation of the chloro-bromo-iodide of silver is perfect.

"This may be known by the disappearance of the violet colour which the back of the paper at first presented; it must not be left longer, otherwise it would lose its sensitiveness.

"The time required to effect this chemical change is from one to five minutes, depending upon the quality of the paper.

"Spread upon a glass, fitted to the frame of the camera, a piece of white paper well soaked in water; upon this place the prepared sheet, the sensitive side upwards.

"The paper which you place underneath must be free from spots of iron and other impurities.

"It is also necessary to mark the side of the glass which ought to be at the bottom of the camera, and to keep it always inclined in that direction when the papers are applied; if this precaution is neglected, the liquid collected at the bottom, in falling over the prepared paper, would not fail to produce spots. The paper thus applied to the glass will remain there for an hour without falling off, and can be placed within that time in the camera.

"When I am going to take a proof at a distance, I moisten the sheet of lining paper with a thick solution of gum arabic, and can thus preserve for a longer time its humidity and adhesion. I can also in this case make use of two glasses, between which the paper is placed, according to the direction of M. Blanquart Everard; but it is necessary to take great care that the plates of glass are perfectly clean, and to have them re-polished if scratched.

"I employ for this purpose, blotting-paper to clean them, as well as my plates; it is much superior to linen, and absorbs liquids and impurities that adhere to it. I never spare the blotting-paper, for I would rather use a leaf too much than be uncertain about the cleanness of my glass.

"When the sheet of lining paper adheres well to the glass, it should not be removed, but only moistened afresh with water, after which you may apply another sheet of the sensitive paper.

"In preparing several sheets of the sensitive paper at a time, it is not necessary to wash the slab for each sheet; you need only draw over it a piece of white paper to remove any dust or pellicle formed.

"When your operations are finished, you may pour back the aceto-nitrate of silver into a bottle, and reserve it for another time.

"The necessity of employing M. Gray's papers in a wet state is their most objectionable quality, but certaialy the results obtained by strict attention to his directions are

often exceedingly beautiful. For developing the image the following is recommended, which does not, however, differ essentially from the developing processes already described:—

"Make about a pint bottle of saturated solution of gallic acid, having acid in excess, and using distilled water; decant a portion into a smaller bottle for general use, and fill up the other bottle; you will thus always have a clear saturated solution.

"Pour upon a slab of glass, kept horizontal, a little of this liquid, spreading it equally with a slip of paper, then apply the paper which has been exposed in the same manner as described for the negative paper, being careful to keep the back dry. Watch its development, which is easily observed through the back of the paper; you may leave it thus as long as the back of the image does not begin to spot.

"When it is rendered very vigorous, remove it quickly to another clean slab, and well wash it in several waters, occasionally turning it, and gently passing the finger over the back; by this means you remove any crystals of gallic acid which might spot the picture.

"The appearance of thei mage at the end of this process will enable you to judge if it was exposed in the camera the proper time.

"If it becomes a bluish grey all over, the paper has been exposed to long; if the strongest lights in the object, which should be very black in the negative, are not deeper than the half tints, it has still been too long exposed; if, on the contrary, it has been exposed too short a time, the lights are but slightly marked in black.

"If the time has been just right, you will obtain a proof which will exhibit well-defined contrasts of black and white, and the light parts very transparent. The operation is sometimes accelerated by heating the gallic acid, and by this process the dark parts of the picture are rendered very black.

"To fix these negative proofs, a very strong solution of hyposulphite of soda, about one ounce of the hyposulphite of soda to four fluid ounces of water, is employed, and the picture is allowed to remain in it until every trace of yellowness is removed from the paper."

Dr. Diamond's Process.—There is one more formula which deserves notice—I mean that of Dr. Diamond, who has been a very successful follower of this process; and I think the reader will be much benefited by a careful perusal of his remarks in his own words:—

"More failures," he says, "than any others depend upon not having good iodized paper, which may result—

"1. From the quality of the paper;

"2. The mode of preparing it;

"3. The want of proper *definite* proportions for a particular make of paper; because I find very different results ensue unless these things are relatively considered. I have not met with satisfactory results in iodizing the French and German papers, and the thick papers of some of our English makers are quite useless.

"Turner's paper of the 'Chafford Mills' make is greatly to be preferred, and therefore I will presume that to be used, and of a medium thickness. The great fault of Turner's papers consists in the frequent occurrence of spots, depending upon minute portions of brass coming from the machinery, or from the rims of buttons left in the rags when being reduced to pulp; and thus a single button chopped up will contaminate a large portion of paper. Occasionally these particles are so large that they reduce the silver solutions to the metallic state, which is formed on the paper; at

other times they are so minute as to simply decompose the solution, and white spots are left, much injuring the effect of the picture.

"Whatman's paper is much more free from blemishes, but it is not so fine and compact in its texture, the skies in particular exhibiting a minutely-speckled appearance, and the whole picture admitting of much less definition.

"It may not be inappropriate to mention here, in reference to the minuteness attainable by paper negatives, that a railway notice of six lines is perfectly legible, and even the erasure for a new secretary's name is discernible in a specimen, which was obtained with one of Ross's landscape lenses, without any stop whatever being used, and after an exposure of five minutes *during a heavy rain*. The sky was scarcely so dense as could be desired, which will be accounted for by the dull state of the atmosphere during the exposure in the camera.

"Having selected your paper as free from blemishes as possible, which is most readily ascertained by holding it up to the light (the rejected sheets doing perfectly well for positives, it is well to reject *all* those upon which *any* doubt exists), mark the smoothest surface; the touch will always indicate this, but it is well at all times not to handle the surfaces of papers more than can be avoided. There is much difference in this respect; some individuals will leave a mark upon the slightest touch, whereas others may rub the paper about with perfect impunity.

"I prefer the paper to be iodized by the single process, because, independently of the ease and economy of time, I think more rapidity of action is attained by paper so treated, as well as a greater intensity of the blacks, so requisite for producing a clear picture in after-printing.

"Take sixty grains of nitrate of silver and sixty grains of iodide of potassium, dissolve each separately in an ounce of distilled water, mix and stir briskly with a glass rod so as to insure their *perfect* mixture; the precipitated iodide of silver will fall to the bottom of the vessel; pour off the fluid, wash once with a little distilled water, then pour upon it four ounces of distilled water, and add 650 grains of iodide of potassium, which *should* perfectly re-dissolve the silver and form a clear fluid; should it not (for chemicals differ occasionally in their purity), then a little more should be very cautiously added until the effect is produced.

"The marked side of the paper being laid upon the surface of this fluid in a proper porcelain or glass dish, immediately remove it, lay it upon its dry side upon a piece of blotting-paper, and stroke it over once or twice with a glass rod; this as effectually expels all the particles of air as complete immersion, it is also more economical, and has the advantage of requiring much less time in the after-immersion in the 'hypo' when it is required to remove the iodide. Either pin the paper up, or lay it down upon its dry side, and when it becomes tolerably dry (perfect dryness is not requisite) immerse it in common cold water for the space of four hours, changing the water during that time three or four times, so that all the soluble salts may be removed; often move the papers, so that when several sheets are together, the surface of each may be equally subjected to the water.

"If this paper is well made it is of a pale straw colour, or rather primrose, and perfectly free from unevenness of tint. It will keep good for several years; if, however, the soluble salts have not been *entirely* removed, it attracts damp, and becomes brown and uncertain in its application.

"Upon the goodness of your iodized paper, of course, depend the future results. Although it is not requisite to prepare it by candle-light, which in fact is objectionable

from your inability to see if the yellow tint is equally produced, I think it should not be exposed to too strong a light; and as the fly-fisher in the dull winter months prepares his flies ready for the approaching spring, so may the photographer, in the dull weather which now prevails, with much advantage prepare his stock of iodized paper ready for the approach of fine weather. Many other ways have been recommended which have proved successful in different hands. Dr. Mansell, of Guernsey, pours the iodide solution upon his paper, which previously has had all its edges turned up so as to resemble a dish; he rapidly pours it off again after it has completely covered the paper, and then washes it in three waters for only ten minutes in all; he considers that thereby none of the size of the paper is removed and a more favourable action is obtained. In the experiments I have tried with the air-pump, as recommended by Mr. Stewart, I have met with much trouble and little success; and I am inclined to attribute the very beautiful specimens which he has produced to his own good manipulation, under favourable circumstances.

"To excite the paper take 10 drops (minims) of solution of aceto-nitrate of silver, and 10 drops of saturated solution of gallic acid, mixed with 3 drachms of distilled water.

"The aceto-nitrate solution consists of—

Nitrate of silver	30 grains.
Glacial acetic acid	1 drachm.
Distilled water	1 ounce.

"If the weather is warm, 6 drops of gallic acid will suffice; and the excited paper thus prepared may be kept longer.

"This may be applied either directly by means of the glass rod, or by floating, as before, and then with the glass rod. If floating is resorted to, then a larger quantity must be prepared. The paper should be blotted off by means of blotting-paper (which should never be used more than once, although preserved for other purposes), and put into the dark frames for use. It is not requisite that the paper should be perfectly dry. This exciting should be conducted by a very feeble light; the paper is much more sensitive than is generally supposed; in fact, it is then in a state to print from, by the aid of gas or the light of a common lamp, and very agreeable positives are so produced by this negative mode of printing.

"I would advise the aceto-nitrate of silver and the solution of gallic acid to be kept in two bottles with wooden cases differing in their shape, so as not to mistake when operating in comparative darkness. A quarter of an ounce of gallic acid put into a three-ounce bottle, and *quite* filled up with distilled water as often as any is used, will serve a very long time.

"I would advise that the paper should be excited upon the morning of the day when it is intended to be used; for there is no doubt the longer it is kept, the less active and certain it becomes. I have, however, used it successfully eight days after excitement, and have a good negative produced at that length of time. The general medium time of exposure required is five minutes. In the negatives exhibited, the time has varied from three minutes to eight, the longer time being when the day was very dull.

"The pictures should be developed by equal quantities of the aceto-nitrate of silver and the saturated solution of gallic acid, which are mixed and immediately applied to the exposed surface. This may be done several hours after the pictures have been removed from the camera. Care should be taken that the back of the picture does not become wetted, as this is apt to produce a stain which will print off upon the positive.

"If, upon the removal of the paper from the slide, the picture is very apparent, by first applying a little gallic acid and immediately afterwards the *mixed* solutions, less likelihood is incurred of staining the negative, from its being more evenly and intensely developed.

"If browning takes place, a few drops of strong acetic acid will generally check it. Should the picture be very tardy, either from an insufficient exposure, want of light, or other cause, a few drops of a solution of pyrogallic acid, of three grains to the ounce of water, and a drachm of acetic acid, will act very beneficially. It sometimes gives an unpleasant redness upon the surface, but produces great intensity upon looking through it. Until the pyrogallic solution was added, there was scarcely anything visible upon this paper, the failure having in the *first* instance happened from the badness of the iodized paper.

"As soon as the picture is sufficiently developed it should be placed in water, which should be changed once or twice; after soaking for a short time, say half an hour, it may be pinned up and dried, or it may at once be placed in a solution almost saturated, or quite so, of hypo-sulphite of soda, remaining there no longer than is needful for the entire removal of the iodide, known by the disappearance of the yellow colour.

"When travelling, it is often desirable to avoid using the hyposulphite, for many reasons—among others, getting rid of extra chemicals; and it may be relied on that negatives will keep even under exposure to light for a very long time. I have kept some myself for several weeks.

"The hyposulphite, lastly, should be effectually removed from the negative by soaking in changed waters.

"Some prefer to use the 'hypo' quite hot, or even boiling, as thereby the size of the paper is removed, allowing of its being readily afterwards waxed. I have always found that pouring a little boiling water upon the paper effectually accomplishes the object; some negatives will readily wax even when the size is not removed. A very hot box-iron is best for the purpose; but the most important thing to attend to is, that the paper should be perfectly dry; and it should therefore be passed between blotting-paper and well ironed before the wax is applied. Negatives will attract moisture from the atmosphere, and therefore the ironing should be resorted to immediately before the application of the wax.

"Before concluding these remarks, I would draw the attention of the reader to the great convenience afforded by a yellow bag, made so large as to cover entirely the head and shoulders, and confined round the waist by means of a stout elastic band. In a recent excursion, I have with the greatest ease been enabled to change all my papers without any detriment whatever, and thereby dispensed with the weight of more than a single paper-holder. The bag is no inconvenience, and answers perfectly well, at any residence you may chance upon, to obstruct the light of the window, if not protected with shutters.

"I would also beg to mention that a certain portion of the bromide of silver introduced into the iodized paper seems much to accelerate its power of receiving the green colour, as it undoubtedly does in the collodion. Although it does not accelerate its *general* action, it is decidedly a great advantage for foliage. Its best proportions I have not yet been able to determine.

"I would also offer a caution upon too great reliance being placed upon the use of gutta-percha vessels when travelling, as during the past summer I had a bottle containing distilled water which came into pieces, and I have now a new gutta-percha

tray which has separated from its sides. This may appear trivial, but when away from home the greatest inconvenience results from such accidents, which may be easily avoided."

Mr. Stewart's Process has been alluded to by Dr. Diamond, and having some claim to the merit of originality, I shall introduce it here, as it may prove useful to some of our amateur photographers, premising that the use of the air-pump, as directed by Mr. Stewart, is highly useful in iodizing the paper in the wax paper process. In the description of his process, Mr. Stewart says :—

"I shall confine myself, for the sake of brevity, to the manipulatory details necessary for the production of negatives.

"*Paper*.—I prefer to all others Whatman's make, as supplied to me by Mr. Sandford; it is rather thick, and does not readily absorb the wax necessary to render it sufficiently transparent; but these objections can be overcome, as will be hereafter explained, while it gives a minuteness as well as mellowness of detail which I have not found in any other. Canson's French paper, and the paper known as 'Papier Saxe,' are good papers, and the most easily handled, being strong and tenacious in their texture. Both stand the action of the air-pump perfectly; the former requires to be carefully selected, it is so irregular and full of defects, but gives very intense blacks; the latter is regular and good, as far as my experience of it goes; it requires longer exposure than the others, being less sensitive when prepared.

"*To Iodize the Paper*, prepare a solution in the following proportions:—Dissolve one ounce (480 grains) of iodide of potassium, and 30 grains of bromide of potassium (I often omit the bromide) in twenty ounces of distilled water, and filter.

"For Whatman's paper it is advisable to reduce the iodide of potassium one-fifth —to about 380 or 400 grains. Pour this solution into a tray, and having cut sheets of paper a little larger than the size finally required for the camera (this is desirable, as the borders are always more or less defective in iodizing, and the paper may, after that operation, be cut to the exact size required), place one sheet floating on the solution, then slip the next sheet edgeways underneath the first, as it floats—doing this smartly, so that the sheet may not lose its rigidity before it has been slid fairly under the first sheet; repeat this with every successive sheet—as many, if necessary, as the depth of the solution in the tray will permit. Any other mode of placing the sheets in the tray will answer, but the above is a rapid, simple, and effectual way of immersing the sheets in the bath, so as to avoid the presence of air-bubbles, and may be employed on all similar occasions. When all the sheets are immersed, cover the upper one with the liquid by raising the whole bundle of the sheets together, and reversing them in the bath, the upper sheet being thus undermost. In four or five minutes, while still in the bath, roll this bundle of sheets up loosely, small enough to be dropped into the glass cylinder, in connection with an air-pump.

"The pump I use is a simple direct-action one; the flexible tube attached to it, and through which the air is exhausted, finishes in a flat lid lined with Indian-rubber (having a valve in the middle), which is placed on the top of, and hermetically closes, an upright glass cylindrical vessel. When the roll of paper is dropped into the glass cylinder, pour over it the solution in the tray in sufficient quantity to cover the paper, and force a piece of gutta-percha or glass down to the top of the roll, in order to prevent its rising in the cylinder, while the air is being exhausted. Then placing the lid on the ground top of the cylinder, a few strokes of the pump suffice to exhaust the air, and the action may be continued as long as the air-bubbles are observed to

escape from the paper to the surface. Generally speaking, four or five minutes suffice for this operation, and the paper may be left a few minutes more *in vacuo* before being removed from the pump. The roll is then picked out, or upset into the tray, and the liquid again poured over it, so that the floating sheets may be easily separated as they are taken out and hung up one by one on an extended cord to dry without previous washing in water. They are now ready for use as required. The operation may be conducted in ordinary daylight.

"With Canson's paper and the 'Papier Saxe,' their sizing is so tenacious there is no fear of continuing the action of the pump too long; but care must be taken with Whatman's paper in submitting it to the action of the pump, as it loses its sizing with great facility. I believe this has been obviated in the more recent manufacture, but it has been an obstacle to the use of that paper. The unsizing is indicated while under the pump, by the presence of a glutinous froth on the surface of the liquid, which does not disappear as bubbles do in water. When the quantity of size set free is very small, the paper may still be used with safety; but the defect is generally discovered in the first sheet used, while developing in the bath of gallic acid. The destruction of the body of the paper, hitherto imperceptible, is now seen, if it exist, while examining the sheet by transparence; and in that case the whole batch iodized had better be set aside, as it is probable most of the sheets are injured. This paper, when perfect, will keep many months, or a year; and as paper thus prepared is employed in all the following processes, a quantity sufficient for a month's consumption can be iodized at once, and put to the necessary test. Should Whatman's paper be now manufactured of sufficient tenacity to resist the action of the pump, there will remain no uncertainty as to its being perfectly iodized and uninjured, and the only cause of failure with that paper removed.

"The solution of iodide of potassium can be preserved indefinitely (replenished only with fresh to replace the quantity absorbed), if it is regularly filtered after use. Should it become very yellow, putting into the bottle a small quantity of starch, and allowing it to digest for some hours, then filtering it, will restore to it its primitive purity.

"*To Render the Paper Sensitive.*—This operation must be performed by the light of a candle or a yellow curtain. In five ounces of distilled water dissolve half an ounce (or 240 grains) of nitrate of silver, and thereto add five drachms of glacial acetic acid, and filter the solution.

"1*st Method.*—Pour the above solution into a perfectly clean tray (which should never be employed for any but silver solutions), and float a sheet of iodized paper on its surface, extending the sheet rapidly, beginning at one end, and lifting it once or twice by the corners, to see that there are no air-bubbles; then cover it up, and leave it thus floating on the silver solution for ten to twelve minutes, or even a quarter of an hour, as it is essential that the solution should thoroughly penetrate the thickness of the paper.

"Should the quantity of the silver bath at hand be small, in lieu of pouring it into a tray (which is rarely quite flat), sufficient may be poured on a plate of glass (the glass, if need be, of a slider), levelled so that none should flow over the sides, and the sheet of paper floated thereon for the same length of time. During this interval, prepare the glass or slate of the camera slides by placing it beside you carefully levelled. If a glass, it had better be finally cleaned with a few drops of acetic acid, to remove any grease, so that water may flow readily over it. Upon this glass or slate pour a layer

of rain or distilled water, just sufficient to cover it. Then taking a sheet of thick bibulous paper (printing) cut to the size of the glass, lay it thereon, so that it at once imbibes the water on the glass, to which it adheres without air-bubbles, and becomes a wet lining to receive presently the sensitive sheet of paper; the excess of water must be removed by lifting up the glass by the corner. Pour over this lining another layer of pure water, and then, on the expiration of the ten or twelve minutes, lift the sheet of sensitive paper carefully up from its bath by the corners, allowing it to drain for a moment; deposit it, floating on the paper lining, the sensitive side (that which was in contact with the silver bath) uppermost towards the operator. The intervening layer of water permits of the sheet being easily adjusted in its proper position; then seizing the glass, and corners of the sheets to prevent them slipping between the fingers and thumb, tilt up the glass slowly and gently so as to allow the intervening water to escape by one corner, when the two sheets will adhere firmly to each other and to the glass, without the presence of air-bubbles. Leaving the glass for a minute or two upright, with the same corner downwards, to allow all the excess of moisture to disappear, it may now be placed in the slider, ready for exposure, taking care not to reverse its position for some few minutes more, lest any drop should re-traverse the sheet and leave a stain. The chief use of the layer of water in this operation, is to prevent the presence of air-bubbles; it also secures the proper position of the sheet without handling it, which, with Whatman's paper, as at present made, is to be avoided as much as possible, it tears so easily. An experienced manipulator can, however, dispense altogether with the layer of water.

"The paper thus prepared for exposure preserves its extreme sensitiveness with its moisture, which, according to weather and climate, may endure an hour or two, within which limit, therefore, the sheet ought both to be exposed and developed. In winter, and cold damp weather; it may remain moist eight or ten hours. When the view to be taken can be reached within that interval of time, this mode of preparing the paper, on which the image is intended to fall directly on the sheet of paper without intervention, the most rich and delicately beautiful results are obtained.

"The time of exposure depends as usual upon the intensity of the light, and upon the nature of the view, whether abounding or not in deep shadows, and also upon the length of the focus and diameter of the diaphragm. With a 3-inch lens, focus of 14 to 15 inches, and diaphragm of 6-10ths of an inch diameter, the exposure for ordinary landscape may vary from a quarter of an hour to half an hour. Paper thus prepared bears very prolonged exposure without injury; I am therefore guided in my operations by the nature and composition of the view; by its darker portions, without much reference to the brighter lights. I also find it safer to expose it a few minutes longer than may be sufficient, no injury resulting from so doing.

"*2nd Method.*—In order to preserve the paper moist in all weathers for one or two days, so as to permit of distant excursions, the following modification of the preceding plan should be adopted. In this operation it is necessary to employ double glasses to the sliders, the paper being placed between the glasses:—

"Plunging the iodized sheet into the silver bath, instead of merely floating it on the surface, cover it entirely with the liquid, avoiding air-bubbles. After remaining 10 minutes in the bath, lift up the sheet, allowing it to drain for a moment, and convey it into another bath of distilled or clean rain-water, to wash off some of the excess of the nitrate of silver. If the paper is to be used within ten or twelve hours, five minutes' washing will quite suffice; if not till the next day, the washing should be

prolonged to ten or fifteen minutes. Should the distilled water, after washing several sheets, become milky, it had better be renewed.

Placing the smaller glass (that which is nearest the lens during the exposure), carefully cleaned with a few drops of acetic acid, on a level,* pour on it a layer of distilled or rain-water. Upon this, float as before the sheet of sensitive paper removed from its water-bath. In this instance it is of no consequence which side of the sheet is downwards, as it is sensitive throughout and on both sides. Inclining the glass, the paper will adhere to it by the escape of the water. Then replacing the glass, with its adhering sheet, on the level, let it be immediately covered with a sheet of wet bibulous paper (or a layer of water can first be extended, and the lining sheet be at once soaked by being floated thereon and adjusted to cover the sensitive sheet, and the intervening water drained off as before), and retaining the glass in the left hand, with the edge of the second glass of the slider grasped in the right hand, inclined at an angle of forty-five degrees, rub twice down the surface of the bibulous paper from one end of the glass to the other, sufficiently hard to force out all the moisture possible, without tearing the paper itself. The second glass is then immediately applied to the paper, to which it clings firmly, is evenly adjusted to the other, and wiped dry; the two adhering glasses, with their imprisoned sheets, are then placed in the slider ready for exposure. Sheets thus prepared remain moist a day or two, and are but little less sensitive than those prepared as first described.

"A *Third Method*, which in certain circumstances may be convenient, is to prepare an iodized sheet, by leaving it immersed as above in the silver bath for ten or twelve minutes, washing it in distilled or rain-water for twenty minutes thereafter, and again in a second bath of distilled water, if desired to remain sensitive for more than one or two days. On removal from the water, hang it up to dry, or, if hurried, dry it between several successive sheets of clean and new blotting-paper.

"To those in the habit of using Mr. Le Gray's waxed-paper process, or any of its modifications, I would recommend, in preference to this last method, to iodize their wax-paper with the air-pump, and use a silver solution of the strength here noted. I have found a decided superiority in the waxed-paper prepared *in vacuo*; it possesses greater vigour, and is capable of much longer exposure without injury.

"In all these processes, the iodide of silver not being confined to the surface of the paper, as in other paper processes, but penetrating the body of the paper, a somewhat greater quantity of silver is expended; and I would recommend all beginners, until they have had some experience, to use in every instance fresh solutions if possible.

"The aceto-nitrate of silver solution should always be colourless; it does not, however, long remain so—discolouring in a day or two. The most effectual way of purifying it, preferable to the use of charcoal *à noir animal*, is, I find, to treat it as follows:—Put a small quantity—say a teaspoonful or less—of kaolin (decomposed felspar employed by the porcelain manufacturers) into about eight or ten ounces of the solution, in a transparent bottle, where it acts as a filter; shake up the solution and expose it to the ordinary daylight for a few minutes, in order to complete the decomposition already commenced, by which time the felspar has subsided, and then the liquid filtered will

* I employ, as a very light portable level, a triangle of brass, formed of three pieces, attached together at the corners by screws, which at the same time can be raised or depressed to produce a level. The withdrawal of one of the screws permits of the pieces being shut up into the size of a small ruler.

pass clear; a few crystals of the nitrate of silver can be added, to restore the strength of the solution.

"*To Develop the Picture.*—An operation also to be conducted by yellow light. The sheet, picked off the slate or removed from between the glasses, is extended as rapidly and uniformly as possible on the surface of, and then immediately covered with, a saturated solution of gallic acid; say a drachm of gallic acid dissolved in a pint and a half of water. This solution should only be prepared when required, and heated a little to hasten its dissolution if necessary.

"A sheet prepared by the first method should be placed in the gallic acid for development, before it has become quite dry, lest it should detach itself from the slate and become stained by touching the slider. For the sheets between glasses, several hours may intervene between the exposure and development.

"If the paper has been sufficiently acted upon by the light, as is almost invariably the case, the development will take place effectually in the simple gallic acid bath. The length of time required varies with the circumstances and the paper employed. Canson's paper develops rapidly, in one or two hours on the average. The paper Saxe is longer in beginning to appear, and then proceeds rapidly. Whatman's paper, though the most sensitive, is the slowest to develop, but supports best the action of the gallic acid. Sometimes two or three hours will suffice for it, but very often ten or twelve hours are not too much, and, if convenient, by removal into a fresh bath of gallic acid, after the first has become dissolved and turbid, it may be left with safety, and often with advantage, double that time in the gallic acid bath. The completion of the development is best ascertained by examining the sheet by transparence. When the whites begin to lose their brilliancy, when the blacks become opaque and well penetrated, it should then be transferred to a tray of clean water. A little experience will serve to indicate when the development is complete, without the necessity of lifting or handling the sheet frequently; the view then appears to be almost lost under a misty veil. The development should even be pushed beyond this point, as the details in the whites (which represent the shadows of the picture) only appear at the very last.

"The stains similar to marbling that are complained of as frequently occurring at this stage of the operations, proceed sometimes from insufficient saturation in the silver bath, but often also from want of cleanliness. To assist in guarding against this last cause, it is well to adopt the practice of never separating the sensitized sheet from its paper lining; but removing the two sheets together from the slider, immerse them so in the gallic acid bath, and leave them thus, the lining undermost, until the development is complete. The sheet is thus preserved by the bibulous paper from the stains occasioned by the deposit on the bottom of the tray. This practice has farther the advantage of enabling the manipulator to handle a large sheet of paper without fear of its tearing, as it otherwise so frequently does by its own weight when lifted.

"In the case of papers sensitized by the second or third methods described above, some eight or ten drops of the silver solution may be added to the gallic acid bath, after the sheet has lain in the bath some ten or fifteen minutes; but this is not always necessary.

"After an hour's immersion in the gallic acid bath, should any of these sheets, when examined by transparence, show blacks still very feeble, owing to insufficient exposure, they can be placed in a fresh gallic acid bath to which ten or twenty drops of the silver solution have been previously added; the opacity of the black is thus

considerably increased by the deposit of silver on them which is thus determined. But this resource should be employed with much circumspection, because it tends to diminish the harmony of the view, by rendering the contrast between the lights and the shadows harsher than they are in nature, depriving the shadows of their due transparency, and producing the unnatural effects seen in some photographic landscapes. The various accelerating processes so frequently recommended, appear to be but this: the exposure in the camera being too rapid to permit of the image appearing under the influence of feeble re-agents, recourse is had to those more powerful, which will always produce an image, provided the paper itself can, without staining, support their action. Hence these processes only succeed well on glass, which can resist their action uninjured. But these chemical re-agents destroy the natural harmony of the image, substituting an artificial effect; because their action, bearing in preference on the blacks, proceeds faster than in the proportion of the action of the light upon each point in the camera. Thus very rapid, but less perfect, proofs are obtained.

"*To Fix the Negative.*—On the removal from the gallic acid bath, the sheets (still by candle-light) should be washed in two or three waters for a quarter of an hour, or they may be left in the water indefinitely till it is convenient to proceed with them; then plunged in a bath of either hyposulphite of soda, or bromide of potassium of the strength of one ounce of either to six or eight ounces of water, or stronger. This process is preferable when abroad, as it does not expose the operator to the risk of staining his work, which the former is so apt to do. When the negative has lain in the hyposulphite bath for about fifteen minutes, it may be examined by daylight to see whether the yellow colour, visible on the back of the negative, or more easily by transparence, has disappeared. If so, the dissolution of the yellow iodide of silver is effected and the operation is terminated. The sheet is then thoroughly washed in water, frequently changed, for several hours. A quarter of an hour or half an hour in the bromide bath suffices to fix the negative temporarily; but it must be fixed as above by hyposulphite of soda on return home.

"The final process, which is generally necessary (though with some of these papers it may be dispensed with), is to wax the negative, when perfectly dry, in order to render it more transparent when required for printing. The most simple mode of accomplishing this is to place the negative face downwards on a sheet of clean paper, rubbing a piece of white wax on a clean heated German iron till the wax melts; spread it all over the proof, as much as it will imbibe. When the sheet is saturated, place it successively on two or three sheets of thick blotting-paper, ironing it all the time till it has parted with its excess of wax. Care must be taken that the iron employed is not too hot; the wax should melt freely when it touches, but without ebullition.

"Whatman's make of paper is sometimes inconveniently thick for printing from, and also receives the wax with difficulty. In that case, after fixing, but before waxing, the negative should be submitted for about half an hour to a bath of concentrated sulphuric acid in the proportion of one ounce to six ounces of water, and then thoroughly washed in several waters. This destroys the sizing, and renders the negative very transparent without injury.

"These directions appear much more tedious in description than they will be found in practice; by following them, paying special attention to cleanliness, the results are so regular and constant, accompanied with so little variation in their repetition under any circumstances, that I think very little experience will suffice to render any beginner expert and certain in his operations. Unless some accident, independent

of the process, intervenes, it rarely indeed happens that on going out for the day with three or four sheets, I do not return with as many different and passable views, no matter almost what the weather may be.

"The second of the preceding methods I find the most convenient for use when absent from home; and where one can carry a small hood, or any means of changing the papers in the sliders protected from daylight, it is necessary to have but one slider, as a thin box will carry six, eight, or ten double glasses with their prepared sheets, to be successively exposed in the same slider as required. I have little doubt, with the aid of the nitrate of zinc, these may, without any material diminution of sensibility, be preserved moist for many days, since at present, with a little precaution they retain their moisture two or three days, particularly if thick English paper has been used."

New Processes.—Many new applications of the calotype processes have been proposed and practised with some success, showing how universal the principle involved prevails in nature. A brief summary of some of these may not be uninteresting to the reader:—

Cyanotype was so called by Sir John Herschel, cyanogen in combination with iron forming a leading part in the process. A piece of paper is washed over with a solution of ammonio-citrate of iron, sufficiently strong to be of a sherry colour. Expose the paper in the camera, and develop the picture by washing it sparingly with common yellow ferro-cyanate of potass, when the negative disappears, and is replaced by a positive of a violet colour, on a greenish-yellow ground.

The *Energetype* consists in the application of a solution of succinic acid two drachms, common salt five grains, mucilage gum arabic half a fluid drachm, distilled water one fluid drachm and a-half, to paper which is afterwards, when nearly dry, washed with solution nitrate of silver, containing one drachm of the salt, to an ounce of distilled water; the paper is exposed in the camera. The image is brought out by the application of a solution containing a drachm of concentrated solution of green sulphate of iron, in two drachms and a-half of mucilage gum arabic.

Amphytype is also a discovery of Sir John Herschel, and receives its name from the fact, that negative and positive pictures can be produced by one process. Paper may be prepared either with the ferro-tartrate or the ferro-citrate of the protoxide of mercury or of lead, by using the cream of the salts, or by successive applications of the nitrates of their oxides, alternating with solutions of the ammonia-tartrate of iron. The proportions of the process are not yet fixed.

THE WAX PAPER PROCESS.

Dr. Percy's Process.—We shall now consider a twin branch of the art. I allude to the wax paper process, first practised by M. Le Gray, and since very successfully by several eminent photographers, amongst the most successful of whom stands Mr. Fenton, whose beautiful views of several cities and places in Russia were all taken by this process; in fact, it is the most useful of any to the traveller who does not wish to be troubled with the incumbrances necessary to the successful practice of collodion; and the remarks of Dr. Percy, which I subjoin, bear me out in this assertion.

Dr. Percy, after remarking that "there is no field in science which promises, at the present time, a richer harvest to those who possess the scientific acquirements which qualify them for its cultivation than photography," continues:—

"Last summer, 1862, it will be remembered, the temperature was unusually high, particularly in the early part of July, the thermometer frequently indicating 90° Fah. in the shade. We shall all long remember the tropical character of that sultry season, —the sun shining without a cloud for days in succession. I heard numerous complaints from photographers, to the effect that they had great difficulty in obtaining pictures, whether on collodionized plates, or on paper; and I met with numerous failures myself with the paper process. There can be no doubt, I think, that these failures were entirely occasioned by the high temperature of the season. I had, before, been constantly accustomed to work successfully with the ordinary paper process in taking landscape views; the iodized paper being excited on the morning of a calotype-excursion, and the image developed in the evening on returning home, after wandering over hill and dale many a mile.

"In cold weather, I have taken tolerably good pictures some days after the excitement of the paper; but, in the season mentioned, I was unable to produce pictures at all satisfactory, unless the process of development took place immediately, or very shortly, after the slide was withdrawn from the camera. The image, if developed at a later period, was most unsatisfactory—the defect being especially conspicuous on viewing the negative by transmitted light. It was porous, and particularly so on the darker parts. The process which I employ is as follows:—

"1. *Solution for the Single Wash.*—To 100 grains of nitrate of silver, dissolved in five fluid ounces of water, add 960 grains of iodide of potassium, which is rather more than sufficient to form a clear solution with that quantity of nitrate.

"2. *Exciting Liquid.*—Seventy-five grains of nitrate of silver, dissolved in one and a-half fluid ounce of water, to which are added two drachms of glacial acetic acid. One or two drops of this solution (known as aceto-nitrate of silver) to one drachm of distilled water, to which are added one or two drops of aqueous solution of gallic acid.

"3. *Developed* by aceto-nitrate and gallic acid diluted with once or twice the volume of water.

"With the waxed paper, on the contrary, I met with excellent results during the hottest part of that sultry season, having obtained a good picture after subjecting it to the following severe test:—I excited the paper in the morning about ten o'clock, and immediately afterwards exposed it in the camera. I withdrew the slide containing the paper, covered it with a black velvet bag, and left it during many hours of the day freely exposed to the brightest sunshine. I developed the image at ten in the evening, and with perfect success. The experiment was made on one of the hottest days in the early part of July. I have made several experiments on this subject, and with the same result.

"Hence it would seem, that one special advantage in the use of the waxed paper is, that it will keep well in hot weather. It may, therefore, be confidently recommended to travellers in hot climates. For travellers, there is no photographic process, which, in respect to convenience, can be compared to the paper process; but unless the paper will keep a reasonable time when excited, the application of this process for landscapes is necessarily very limited. The traveller should be able to excite the paper over night, and walk from place to place with his camera,—take any views which he may desire, and return home in the evening to develop them. Unless he can do this, he must have his portable tent, and carry about with him all the necessary apparatus for manipulation. In certain cases, as in rambles in the East, it may be desirable, from other considerations, to have such a tent, in which calotype manipula-

tions may be also practised; and, in such cases, the objection to the processes, in which the excited surfaces will not keep, does not so strongly apply. But, even then, it is far better, when practicable, that instead of returning from time to time to his tent for the purpose of developing, he should be enabled to take his views at once, and conduct all the developments together. A process, then, is required for travellers, especially in hot climates, in which the greatest portability of apparatus may be obtained; and where the material upon which the image is to be received will keep for a sufficient time after excitement and exposure in the camera, and without the liability to be injured or broken like glass: Now the paper process is exactly adapted to meet these conditions; and, with respect to landscapes, our efforts towards improvement should be specially directed to that process.

"As the waxed paper will keep so well after excitement and exposure in the hottest weather, it might be anticipated that, *ceteris paribus*, it would keep proportionately longer than ordinary paper under ordinary circumstances of temperature in this climate. And the anticipation generally accords, I think, with the experience of photographers. One of the best negatives I ever saw was on waxed paper; it was taken by Vicomte de Vigier a month after excitement. The scene was part of the Forest of Fontainebleau. I have also myself obtained pretty good results with the use of waxed paper excited several days previously.

"In the ordinary paper process, however, I have not succeeded in obtaining an image, worthy of being called a picture, longer than five days after exciting; though some photographers have informed me that they have obtained good pictures a considerably longer period after the exciting process.

It is not my intention to enter upon an exact comparison of the relative merits of the waxed and the ordinary paper process. As the waxed paper process is at present effected, I have no hesitation in expressing my strong predilection in favour of the old paper process for landscapes in this country, under ordinary circumstances of temperature. The long time required in bringing out the image in the waxed paper process is a serious objection—several pictures requiring many hours' attention in their development.

"In the waxed paper process, the sky is generally obtained of a beautiful and intense black, and the limit between it and very distant objects is, generally, well-preserved. In negatives obtained by the ordinary paper process, the sky may also be occasionally obtained very black; but, in my experience, this blackness of the sky in the latter process is not nearly so uniformly attained as in the waxed paper process. Much might be said on the special conditions of weather which appear to be most favourable to the obtaining of well-defined distances in calotypes of landscapes, trees, &c.

"On the other hand, I am not quite satisfied, that in an exact comparison between a good negative on paper, such as Turner's, and a waxed paper negative, the superiority must not be ascribed to the former. From what I have seen, I should, especially in respect to beautiful gradation of tint, be inclined to say that the old paper process has the advantage. When we reflect that in the ordinary process the image is comparatively superficial, whilst in the waxed-paper process it penetrates and exists in the very substance of the paper itself, we might expect that, in regard to the quality mentioned, the former would excel the latter. In the one case, there is only the irregularity of the surface to deal with; whereas, in the other, there is the irregularity of the entire thickness of the paper itself."

M. Le Gray's Process.—Next for consideration will be the original method, as practised by Le Gray himself, with modifications by others of his successful followers. To M. Le Gray we are indebted for this and several other improvements in the calotype, and for the following modification of the wax paper process. He dissolves, in a *bain-marie* or flat iron pan, 300 grains of good isinglass, in a litre of distilled water; of the gelatine thus formed he takes about eleven ounces, to which he adds half an ounce of iodide of potassium, 120 grains of bromide of potassium, and 60 grains of chloride of sodium. When this mixture is thoroughly incorporated and filtered through fine linen, and before it is cool, he dips his previously selected paper, piece by piece nto it, withdrawing it at the end of some few minutes, when it is suspended by a corner to dry. This operation can be performed in a full light, and the paper thus prepared is said to preserve its sensibility for months.

More recent French photographers suppress the bromide of potassium and the chloride of sodium altogether, augmenting the iodide of potassium to 300 grains. At a subsequent period M. Le Gray claimed the discovery of the wax process, although it seems doubtful if he was the first who practised it; at least the following statement gives a different version of the discovery.

M. Fabre's Process.—We find in the journal *La Lumiere* a highly interesting communication from this gentleman from Rome, which seems to be the first public notice of the waxed paper process. "I have long discontinued the glass in favour of a modification of the wax paper and albumen process," he says, "and with most satisfactory results. The blacks and whites are excellent, and the half tints much softer than in the other process." The writer proceeds to describe his process, which is as follows:—

Selecting the most suitable paper within his reach, a leaf, dipped in pure melted wax, is placed between two other leaves free from wax. An iron, such as is in use in the laundry, made moderately hot, is drawn over the paper, and suffices to wax the two other leaves with the superfluous wax. In this manner thirty or forty pieces may be waxed at once. To the waxed paper thus prepared albumen is applied as directed for the glass process. The coating of albumen being dry, a bath of acetic acid is applied to the albuminized side. The aceto-nitrate bath is now made use of, as in the ordinary paper process, to excite the albuminized side of the paper. The result was, as we have stated, highly satisfactory to the author of the paper.

On the publication of M. Fabre's note, M. Le Gray claimed the credit of having previously communicated the process in a paper addressed to the Académie des Sciences; however that may be, M. Fabre appears to have made the first public announcement of an application of wax paper to photography. M. Le Gray's process is as follows:—

"*First Process: To Wax the Paper.*—This process divides itself into several parts, waxing the paper being the first. For this purpose he takes the paper prepared by Lacroix d'Angoulême, or that of Canson brothers of Annonay. A large plate of silvered copper, such as is employed for the Daguerreotype, is obtained and placed upon a tripod, with a lamp underneath it, or upon a *bain-marie*. The sheet of paper is spread upon the silver plate, and a piece of pure white wax is passed to and fro upon it until, being melted by the heat, it is seen that the paper has uniformly absorbed the melted wax. When this has thoroughly taken place, the paper is to be placed between some folds of blotting-paper, and then an iron, moderately hot, being passed over it, the bibulous paper removes any excess of wax, and a paper of perfect transparency is obtained.

"*Second Process: To Prepare the Negative Paper.*—In a vessel of porcelain or earthen-

ware capable of holding five pints and a quarter of distilled water, put about four thousand grains of rice, and allow them to steep until the grains are but slightly broken, so that the water contains only the glutinous portion. In a little less than a quart of the rice solution thus obtained, dissolve—

Sugar of milk	620 grains.
Iodide of potassium	225 „
Cyanide of potassium	12 „
Fluoride of potassium	7 „

The liquid, when filtered, will keep for a long time without alteration.

"When you would prepare the paper, some of this solution is put into a large dish, and the waxed paper, sheet by sheet, is plunged into it, one over the other, removing any air-bubbles which may form. Fifteen or twenty sheets being placed in the bath, they are allowed to soak for half an hour, or an hour, according to the thickness of the paper. Turning over the whole mass, commence by removing the first sheet immersed, and hooking it up by one corner with a pin bent in the shape of the letter S, fix it on a line to dry, and remove the drop from the lower angle by a little bundle of blotting-paper. M. Le Gray remarks that French and English paper should never be mixed in the same bath, but prepared separately, as the 'English paper contains a free acid which immediately precipitates an iodide of starch in the French papers, and gives to them a violet tint.' The paper, being dry, is to be preserved for use in a portfolio; even in this state it is not absolutely insensible.

" *Third Process: To render the Waxed Paper Sensitive.*—Make a solution of

Distilled water	2325 grains.
Crystallized nitrate of silver . . .	77 „

and when this is dissolved add of

Crystallized acetic acid	186 „

" Papers prepared with this solution will keep well for a few days. M. Le Gray, however, recommends for his waxed paper, and for portraits, that the quantity of nitrate of silver be increased to 155 grains; the paper must be used moist.

"The method of preparing these papers is to float upon an horizontal plate of glass either of the above solutions, and taking a piece of the iodized paper, to carefully place it upon the fluid, taking great care that no air-bubbles interpose. The paper must remain a short time in contact with this sensitive fluid until chemical combination is effected. Four or five minutes are required for some papers, and eight or ten seconds are sufficient for other kinds. When a violet tint appears the paper should be removed.

" For those papers which it is desirable to keep for some time, as during a journey, it is recommended that into one vessel of porcelain you put about five or six millilitres of the strong aceto-nitrate above described, and into another some distilled water; plunge completely both sides of the waxed and iodized paper in the first fluid, and allow it to remain about four or five minutes; withdraw it, and plunge it immediately into the bath of distilled water, in which let it soak for not less than four minutes. When these papers are carefully dried they may be preserved for some time for use, and by lessening the dose of nitrate of silver this period may be considerably prolonged. It will, of course, be understood by all who have followed the processes described up to this point, that the papers which are prepared for keeping are not those which are the most sensitive; hence it is necessary to expose them a much longer time in the camera than those prepared by the stronger solution of silver. The more

sensitive paper, under ordinary circumstances of light, will require an exposure in the camera of about twenty seconds, the less sensitive demanding about ten or fifteen minutes, according to the circumstances of light.

"*Fourth Process: The Development of the Image.*—The picture is developed by the aid of gallic-acid dissolved in distilled water. Le Gray finds the following to be the best proportions:—

Distilled water	40 fluid ounces.
Gallic acid	60 grains.

"The paper is to be plunged into this solution, and allowed to remain until it is fully developed. The time will vary from ten minutes to two hours, or more, according to the intensity of the rays incident on the paper when in the camera. The development of the image is much accelerated by the addition of fifteen or twenty drops of the aceto-nitrate of silver.

"*Fifth Process: Fixing.*—It is often found convenient, when on a journey, to give a temporary fixedness to the pictures obtained, and to complete the process with the hyposulphite at any time on your return home. A wash of 360 grains of bromide of potassium to two quarts of water is the strength which should be employed. The process of fixing with hyposulphite consists, as in other preparations, simply in soaking the paper until the yellow tint of the iodide has disappeared."

The reader cannot do better than study the conclusions arrived at by Mr. W. Teasdale, as the results of a number of carefully-performed experiments on the wax-paper process, and which he has put in a tabular form, for the more easily comparing one process with another. After enumerating the peculiarities which give the practice of the paper processes advantages in many respects over the Daguerreotype, the collodion, and the albumen processes, he proceeds to the consideration of the employment of waxed paper as a prominent modification. The value of the wax depends not merely on its filling up the pores and producing a uniform surface, but on its giving greater transparency, strength, and a tenacity, which is very advantageously experienced in the washings. He considers, also, that the pictures are more free from spots or stains.

"*Paper.*—The choice of paper (Mr. Teasdale says) is of less importance than in the ordinary calotype process. The texture should be uniform, and the sizing wholly organic. Whatman's, Turner's, and other papers made in England, though smooth, firm, and of even texture, are all sized with gelatine (glue), which not only has a tendency to retard photographic action, but renders the paper so dense, that the author has found it necessary to soak it in warm water and dry it before waxing. They also curl up strongly when floated on one side; are less transparent, so that air-bubbles are more readily overlooked in the exciting and other operations; they do not assume the desirable violet tint after iodizing, and the finished negative prints very slowly. Some of these papers, however, seem to bear prolonged development better than the French. The papers of Canson, Lacroix, and other French makers, are almost wholly sized with starch; this increases their sensibility, and is readily permeable by the wax. Though very thin, these papers are remarkably tenacious; but the texture, especially of the 'Lacroix' and 'New French,' is not exactly all that could be desired. The principal defect in Canson's is the presence of minute particles of metallic substance, which, unless removed by the process hereafter described, or some other, produce spots and spoil the beauty of the negative. The paper preferred is what is known here as 'New French,' the only defect of which is the texture, which does not allow of the sharpness

of outlines required by the architect or engineer; but this would doubtless lead the artist to prefer it.

"*Waxing.*—A cheap and easy method is to employ a thick oven-shelf, which, when once heated, will be available for a considerable number of sheets. On this is placed a clean sheet of common tin plate, which must be used for this purpose alone, and kept carefully wrapped in paper when not in use. Each sheet of paper is to be laid on the tin plate, and rubbed over with a piece of wax; the perfect penetration of the paper may then be assisted by rubbing with an ivory paper-knife or the handle of a tooth-brush. The author employs the economical and easily-regulated heat of a number of gas-jets, over which the plate stands on a common kitchen trivet. When the requisite number of sheets have been waxed, they are ironed separately in blotting-paper; not, as is usually directed, to extract as much as possible of the wax, but to remove only as much as is necessary to produce a smooth surface.

"*Iodising.*—This operation is of the first importance. It is therefore desirable to consider the photographic effect the various substances are calculated to produce.

"*Rice-water* is commonly recommended as the vehicle, on account of the starch it contains; it is useful for unsized or previously washed papers, but for French papers, which usually contain an excess of starch, the author prefers pure water, especially if the solution contains organic substances, such as sugar of milk, albumen, &c., in addition to the alkaline salts.

"*Iodide of Potassium.*—The quantity recommended by Le Gray and others is far too small, unless thick paper is used and the light is strong. To obtain intense blacks and graduated shades on French papers, the author at least doubles the quantity, unless operating under a bright sunny sky.

"*Bromide of Potassium.*—Using achromatic lenses, the author employs a small quantity of this salt, which accelerates the effect by its peculiar sensitiveness to certain rays, but if much bromide is added the paper is rendered slow; however, if insufficiently exposed, it bears prolonged development without injury to the whites of the negative. It is probably the large proportion of this salt in the Vicomte Vigier's solution, that renders papers prepared with it capable of retaining their sensibility so long.

"*Cyanide of Potassium* the author was long opposed to, on account of its retarding effect and the reduction of intensity; but these disadvantages are more than compensated by its penetrating the wax so readily, taking from it the greasy appearance, facilitating the saturation with the other salts, preserving the whites, and rendering the negative cleaner and more transparent.

"*Fluoride of Potassium* the author uses in small quantity, like many other persons, solely on the authority of the French operators, who attribute to it a power of increasing the sensibility greatly, which no one seems to deny.

"*Chloride of Sodium*, used sparingly, is a valuable agent in giving intensity to the blacks, and slightly increasing the sensibility; if in excess, great care is requisite to prevent solarization.

"*Organic Substances.*—With the exception of the starch sizing, sugar of milk is the principal; like other matters of the same class, it facilitates the reduction of the metallic salts, gives dense black skies, and modulates the tones of the pictures. The author uses a small quantity of honey, because continental photographers state that it increases the sensibility; probably the use of gum arabic, as recommended by Mr. Ramsden, answers the same purpose. White of egg (albumen) is commonly used,

without any particular reason being given. The author employs it simply for the sake of improving the appearance of the finished negative, to which it gives a slight gloss. Mr. Fenton thinks it renders the paper slower. Isinglass is used only by Le Gray. The author does not attribute any advantages to it, and finds it renders the solution so thick and glutinous that air-bubbles can scarcely be avoided.

"*Iodine.*—By far the greatest improvement in all the iodizing solutions is the addition of free iodine in considerable quantity, as suggested by Mr. Crookes. This certainly has the power of removing metallic specks from the paper; and as the iodized papers have, before being excited, a dark purple colour, the presence of an air-bubble cannot escape detection, and the process of exciting is rendered easy and certain. If the solution contains any cyanide of potassium, a much greater quantity of free iodine will be required than when none of this salt is present.

"*Exciting.*—It is stated by Mr. Hunt, that when iodide of silver is made by mixing solutions of nitrate of silver and iodide of potassium, the more dilute the original solutions are, the more sensitive will the precipitated iodide be. The author's experiments confirm the doubt this raises as to the truth of the common opinion, that the sensibility of the paper is in direct proportion to the strength of the silver solution; and he employs a weak solution of nitrate of silver, using a proportionately larger quantity of this solution, whereby (he thinks) the manipulation is rendered easier, and the sensibility greater and more equal over the whole sheet.

"With the view of increasing the sensibility of papers not required to be kept long, the author has tried the effect of exciting solutions containing less acetic acid (generally fifteen grains of glacial acetic acid to every ten grains of nitrate of silver in the solution) than is recommended by Le Gray and others; but has had more failures from this cause than from any other, the pictures becoming brown in the development, especially if long continued.

"The method employed to prepare, say six or eight sheets, is as follows:—Upon a large piece of plate glass levelled by screws, are poured four drachms of a fifteen-grain solution of aceto-nitrate of silver; the marked side of a sheet of iodized paper is floated upon this, prevented from curling up by breathing gently on it, and carefully raised at each corner to see that every part of the under surface is wetted. It is allowed to remain untouched for four or five minutes after the last traces of colour have disappeared from the upper surface, which must be preserved from contact with the solution, to avoid the probable production of black spots on the back. Removed from the silver solution, the paper must be floated for a few minutes upon a pint or so of water (which will serve for the whole six or eight sheets), holding the sheet by the corner and slightly agitating it. Then it is pinned up to dry, without blotting off, merely attaching a morsel of blotting-paper to the lower corner to assist the rapid draining away of the liquid. If the upper corner is dried by pinching it between the thumb and finger, silver pins need not be used, as then no liquid will run down. For every fresh sheet, add about two drachms of fresh aceto-nitrate solution to that on the glass plate, and proceed as before. When the sheets are all excited, pour the aceto-nitrate remaining on the plate into a separate bottle for use in the development; the quantity barely sufficing, none is wasted except what is lost in the washings, and this may be recovered if thought worth while. It may be better, but is by no means necessary, to use distilled water or filtered rain-water for washing. The water used by the author is well-water, containing salts which precipitate silver, but he finds no difference in the result, whether he uses this or perfectly pure water.

"It is convenient, for many reasons, to use one standard size of paper, such as a quarter-sheet, 11 × 9 inches, for a 3¼ lens, or a sixth, 9 × 7½ inches, for one of 2¾ inches diameter. The latter is always used by the author.

"It is a generally received opinion that in iodizing the sheet, the maximum of sensibility is attained at the moment when the last trace of violet or purple colour vanishes, and that it then begins to diminish, unless the paper is removed. The author considers this to be erroneous; he believes the paper only attains its maximum of sensibility several minutes after the colour disappears, and that the sensibility is not diminished if the paper is left five, ten, or fifteen minutes longer on the exciting solution.

"*Exposure.*—The requisite time of exposure depends on so many circumstances—the lens, the diaphragm, the season, weather, hour of the day, character of view, &c.—that no safe general rule can be given. Perhaps for a landscape in diffused light, in fine clear weather, an average of twenty minutes with a Ross lens two and three-quarters inches, and a half-inch diaphragm, will be about the best. With paper used wet, as in Flacheron's process, probably three or four minutes would suffice; but the whole manipulation would then be different, and the view must be taken and developed soon after exciting. The author cannot state how long his paper might be kept after exciting. Sheets kept eight or ten days in autumn had not lost much; requiring perhaps five minutes longer exposure.

"*Developing.*—It is best to prepare gallic acid in a quite saturated solution, four ounces of which should be poured into the dish and one ounce of pure water added. When thoroughly mixed, the marked side of the negative is to be floated on it, breathing on the back slightly as in exciting, for the same reason; it should be left five or ten minutes at least before adding any aceto-nitrate, and if the operator has not time to watch the development and arrest it at the right moment, the picture may be safely left for many hours floating on the gallic acid solution; this, if the picture has been over-exposed, will be the best method to prevent its being spoiled by solarization. In either case, when the operator has time, the negative should be taken from the dish with one hand, while with the other the two or three drachms of the refuse aceto-nitrate solution above mentioned should be added and well mixed, and the negative then replaced upon it. The time required to develop the image will enable the operator to judge whether an additional quantity of aceto-nitrate should be added. When the image is fully brought out, drain off the developing liquor, pour clean water into the dish, changing it once or twice, then turn the negative face upward and brush it with a camel's-hair pencil kept expressly for this purpose. If not convenient to fix it at once with the hyposulphite of soda, it may be kept for a length of time, along with others, in a portfolio.

"Considerable latitude is allowable as to time of exposure, as error in this respect may be counteracted subsequently. If too short, so that in the longer development required the picture turns brown and will scarcely print, the transparency may be restored without injury to any of the blacks, by immersion in a dilute solution of cyanide of potassium, about sixty grains to one pint. This will sometimes remedy solarization also. If the development has been arrested too soon, the fixed and finished negative may be improved by floating it on a solution of chloride of gold, such as is used for giving a deep violet tint to positives.

"The reason for floating the negative and developing on one side only, is to preserve the cleanliness of the picture, and to prevent the stains and marbling often arising from dirty dishes; the black deposit formed during the long development sinks

to the bottom of the dish, and is never touched by the floating negative. Le Gray recommends acetic acid for removing stains and spots, but the author does not find this agent available, while the partial use of cyanide of potassium, which alone produces the effect, spoils the beauty of the negative."

I may here remark that, to amateurs generally, one of the most annoying causes of failure in the wax-paper process is the marbling appearance which occurs with some of the most beautiful negatives, and spoils them as perfectly as if they were soaked in ink. This arises from the use of dirty dishes for the various solutions, particularly those for the nitrate and gallic acid baths, but more especially the latter. Even though they may *seem* clean, and though the picture is not even allowed to touch the bottom of the dishes, the marbling may show itself in the picture during development. To insure perfect cleanliness, then, which is more necessary in the waxed paper than in any other photographic process, the dishes should always be thoroughly washed and rubbed dry with a clean cloth, both before and after use, and a separate dish should be used for each solution. In this, and in all the other photographic process, it is almost an impossibility to be *clean enough*, therefore never spare clean cloths and plenty of water, and having once put the sheet of waxed paper into either the exciting or developing dish, never take it out again, or lift it without previously skimming the surface of the liquid; this is done by means of a strip of blotting-paper held by each hand, and drawn along the surface, edge down.

The following, being Mr. Teasdale's Table of Comparison, may be useful to the photographer.

TABLE OF THE WAXED PAPER PROCESS.

Iodizing Solutions.

Vehicle.	I. Le Gray.	II. Puloh.	III. Vigier.	IV. Fenton.	V. Ramsden	VI. Crookes.	VII. W. Hunt.	VIII. Teasdale.
	Rice water.	Distilled water.	Boiled whey.	Either distilled or rice water.	Rice water.	Distilled water.	Rice water.	Distilled water.
Iodide of potassium	120	140	220	350	90	480	120	240
Bromide	.....	8½	35	10	.....	.....	70	20
Cyanide	6	8½	17	17	.....	.....	.....	8
Fluoride	3¾	4¼	13	8½	.....	.....	48	16
Chloride of sodium	.....	.....	.....	26	.....	.....	70	10
Sugar of milk	360	132	.....	350	240	.....	160	240
Honey	.....	88	.....	44	.....	.....	.....	50
Albumen	480	480	480	480	.....	.....	.....	480
Isinglass	120 ?	.....	.....	.....	.....	.....	.....	.....
Gum-Arabic	.....	.....	.....	.....	50	.....	.....	.....
Free Iodine	1 or 2	.....	.....	sherry colour.	nearly a port wine tint.	sherry colour.	ad libitum.	deep port tint.

Exciting Solutions.

Nitrate of silver	32	.....	.....	32	35	15	10 or 12 used wet	15
Gl. Acet. Acid	36	.....	.....	36 (less if to be kept longer.)	35	15	——— ?	20 to 25

"*Remarks on the Table.*—I. The large proportion of organic matter in M. Le Gray's solution, renders it too thick and glutinous. The albumen represents one ounce, or the white of a single egg, expressed in grains to preserve uniformity, and to facilitate comparison of the proportion of organic substances in each solution. The small proportion of iodide is not suited for thin paper; it however possesses the advantage of sustaining uninjured the prolonged action of the developing agent better than many others.

"II. Mr. Pulch's solution is very sensitive, but does not keep well; and turns brown if the development be continued too long.

"III. Viscount Vigier's solution will keep uninjured, after exciting, longer than any other (say in winter six or eight weeks), but is very slow in its action.

"IV. Mr. Fenton's solution is very good, especially for the thin old Canson's paper made some years ago.

"V. Although I have not been very successful in using Mr. Ramsden's solution, it has produced, in other hands, the best negatives I have ever seen. It would be better, I think, to double the quantity of iodide.

"VI. Mr. Crookes' solution has given me one or two good pictures, but requires at least the addition of some organic matter, such as sugar of milk or rice water.

"VII. Mr. Hunt has given this solution as the result of a connected series of carefully made experiments on the use of the bromides; but it is to be regretted that he used common meniscus lenses, in operating with which I think the peculiar value of the bromides is not apparent.

"VIII. I have been led to adopt my own iodizing solution for general use from experiments with, and consideration of most of the preceding."

M. Geoffroy's Process.—Before leaving the wax paper for the present we shall devote a few minutes to the consideration of a new method of preparing waxed paper, by M. Stephane Geoffroy, of Roanne:—

"1. M. Geoffroy places 500 grammes (about eighteen ounces avoirdupois) of yellow or white wax, and one litre (about a quart) of alcohol of commercial strength in a glass retort, and boils the alcohol until the wax is completely dissolved, having previously attached a receiver to the retort to collect all the products of distillation, he then pours the still fluid mixture into a glass vessel, and as it cools the myricine and cerine solidify, while the ceroleine remains in solution; this liquid is separated by passing it through fine linen, and, as a final operation, mixing it with the alcohol which passed over in the distillation, and filtering it through paper in a glass funnel. A store of this liquid is kept in a carefully stoppered bottle, to be used as required in mixture with the following.

"2. He then dissolves in 150 grammes (about five ounces) of alcohol of 36° twenty grammes (five drachms Apoth. W.) of iodide of ammonium (or potassium), one gramme (about fifteen grains) of bromide of ammonium or potassium, and one gramme (about fifteen grains) of fluoride of potassium or ammonium.

"Taking a capsule he pours drop by drop upon about one gramme (about fifteen grains) of iodide of silver freshly prepared, as much of a concentrated solution of cyanide of potassium as is required to dissolve it.

"This dissolved iodide of silver he adds to the preceding mixture, and agitates it; there remains at the bottom of the bottle a rather thick deposit of all the above salts, which serves to saturate the alcohol, with which that already saturated is successively replaced, and removed in the manner and proportions to be described.

"3. These two bottles being ready, when about to prepare negatives, he takes about 200 grammes (six and-a-quarter ounces Apoth. W.) of the solution No. 1, of ceroleine and alcohol, with which he mixes twenty grammes (five drachms Ap. W.) of the solution No. 2. Filtering the mixture with care, to avoid undissolved crystals, which spot the paper, he makes a bath in a porcelain dish, wherein he soaks for about a quarter of an hour, five or six at a time, papers previously selected and cut to size; continuing to do so until the solution is exhausted. Taken out, hung up by a hook in one corner and dried, these papers, which have acquired a very uniform rose tint, are covered up from dust and kept dry. In rendering them sensitive with nitrate of silver, developing with gallic acid, and fixing the proofs with hyposulphite of soda, the ordinary method is followed—generally that of M. Le Gray—adding one or two grammes (fifteen to thirty grains) of camphorated spirit of wine to one litre (about one quart) of the solution of gallic acid."

The great advantages M. Geoffroy found in preparing his negatives by this method are as follows:—

"All who use paper waxed by M. Le Gray's process, are aware of the slow and difficult preliminary operations required previous to rendering it sensitive with nitrate of silver. They know how much precaution is required to obtain paper uniformly coated and unspotted, in the midst of such long operations, where the chances of accident are so numerous, the constant attention required to guard against the impurities of the wax of commerce, against dust during the impregnation of the paper and the ironing, against too great heat in the latter, and against bad quality of the paper used for absorbing. Photographers also know how much wax is lost in this process, and what the quantities of paper necessarily cost in absorbing properly. The difficulty and tediousness of the imbibition of an aqueous solution by paper previously waxed is equally known. On the other hand, by the method here described, the iodizing and waxing are effected in one simple and rapid operation; the imbibition is, as may be imagined, very uniform and complete, from the facility with which alcohol penetrates; and that granular appearance which is so troublesome in ordinary waxed proofs, is avoided by this method, owing to the character of the ceroleine—this substance possessing elasticity in a remarkable degree.

"The solution of ceroleine in alcohol is moreover very easily prepared, and comparatively cheap, for the residues of stearine and myricine may be either sold or used with excellent effect for waxing fixed proofs.

"The solution made by the above formula is photogenic in a very high degree; indeed, when used with either thin or thick papers, it gives, from the first bath of gallic acid, blacks of an intensity which it is impossible to obtain with Le Gray's paper, and, which other papers scarcely acquire after having been treated a second time with acetic acid or bichloride of mercury. At the same time, they preserve the whites and half-tints in a manner which surprised me. The transparency of the proofs is also admirable, and the clearness of the image yields in nothing to that of proofs obtained upon albumen."

Lespiault's Process.—The following process by Lespiault is considered useful in some cases, and is very easily prepared; but I cannot personally speak as to its merits, not having tested it:—

"The prepared papers do not," says M. Lespiault, "keep very long in the hot season; but if they are sensitized in the morning, or even overnight, they will keep the whole day if care is taken to wash them in three fresh waters. I am speaking of

the papiers Saxe, the only sort that I habitually use. Turner's keeps much better, but it is only half so rapidly sensitized. This is the formula for the preparation of the iodide :—

Eau de vie, from 18° to 20°	.	500 grammes (16 ounces).
Sugar of milk	. .	to saturation.
Iodide of zinc	. .	10 grammes (150 grains).
Bromide of zinc	. .	2 grammes (30 grains).

"The quantities of iodide and bromide indicated above may also be dissolved in 250 grammes (8 ounces) of distilled water; saturated with sugar of milk; and 250 grammes (8 ounces) of alcohol added to this solution.

"The papiers Saxe immersed in this liquid for four or five minutes take a very even rose tint in drying. The paper can be kept in this longer without any bad effect.

"These papers, once dry, will keep indefinitely; when it is wished to sensitize them, float them on a bath of aceto-nitrate of silver of five per cent. with the addition of from seven to eight per cent. of glacial acetic acid.

"The paper becomes little by little very white; at the end of four or five minutes, when the tint is very equal, it is taken out, and immersed in a bath of distilled water: this should be renewed three times, allowing a quarter of an hour between each time, and dried afterwards with blotting-paper, and the operations continued the same as with the wax-paper.

"If the bath of aceto-nitrate were more concentrated, by ten per cent. for example, the paper would not keep, and the print would want delicacy; if it were weaker it would be liable to unsensitized patches, or it would be necessary to keep the paper much longer in the liquid. This observation applies, I believe, to all negative papers, and, above all, to those which are not waxed.

"Using a lens of three inches in diameter, fifty centimetres (about thirty inches) of focal length, with a diaphragm of fifteen millimetres, a quarter of an hour's exposure, instead of thirty-five minutes, is sufficient for photographing an old building or a street. Trees can be taken in the same space of time, if a diaphragm with an opening large enough is employed, but, with the same diaphragm, it takes forty minutes. It takes an hour and a-half with waxed or albuminized paper. I attribute this enormous difference in rapidity to two causes: first, to the different bases of the iodides; and, secondly, to the absence of any fatty substance, such as wax, which retards more or less the formation of the image. If the paper has not been altered by the heat and the remains of the nitrate which has not been removed by the washing, the whites can be preserved two hours in the bath of gallic acid. The prints so obtained are delicate, and without roughness; and the blacks are always sufficient when the time of exposure has been suitable."

In conclusion, I must say that half the failures result from *impure wax*. The fact is well known that the white wax generally sold as purified wax *is more than half adulterated* with *foreign substances;* here we have a cause of failure to be only got rid of by going to a respectable wax-bleacher, and telling him for what purpose the wax is required. Another cause of failure or *graining* in the negative, although that just mentioned is the greatest, is using the iron too hot when waxing. More than half the success of the wax paper process depends on the perfect manner in which the paper is waxed and the purity of the wax employed.

Summary.—Having given, in the preceding pages, the different formulæ of some

of the most eminent and successful operators, it now remains to give the reader some practical observations on the manipulatory portion of the information already conveyed. To begin, then, with the beginning, the first subject for examination will be the causes of failure in "THE CALOTYPE PROCESS."

The causes of failure in the calotype, as in *all* the other branches of photography, are numerous; and, I am sorry to say, in reference to the science in general, that the causes of these failures are nearly always to be traced to the inattention, carelessness, or *dirty habits of manipulation*, in the operators. I say *dirty habits*, for there is nothing so easily acquired, *or so difficult to get rid of*, as a slovenly, dirty, method of manipulation. As an instance, I had a friend—in fact, a pupil—some short time back, who was constantly writing to know the cause of this failure and of that. Now, he was remarkably clean and neat in his habits and person, so much so that I never for a moment thought, after I first mentioned the subject, that his failures could arise from any want of care in that direction, and I was fairly puzzled to account for some of them, knowing that his chemicals and apparatus were of the first quality. At last I determined to pay him a visit. I found that he had gone to some degree of expense as an amateur in fitting up a glass-house, dark-room, &c.; and could plainly see that it was not from want of expensive materials, or persevering trials, that he failed; so I said to him, "Well, I have come to see you work; so commence as soon as you like—I shall be your sitter." He commenced in a first-rate style of activity, took up a glass plate (he was working the collodion), picked up a piece of old linen that was lying on the developing bench in his dark room, with which he polished his glass, coated it, and plunged it in the bath. He then proceeded to arrange and focus me; he had a curtain over a beam, for the purpose of shading one side of the face, and in his usual energetic manner he gave this curtain a pull, in order that he might place it where he wished, and drew it suddenly along the beam (which I am sure had a month's dust on it), and set a cloud floating about the room that would take at least three hours to clear away. He then put the plate in the camera, and, after exposing, he took up the glass holding the developing solution from out of a mess of wet, &c.; and, in pouring the developing solution on to the plate, he let a couple of drops fall on the latter from the bottom of the developing glass, furnished by some of the indescribable mess in which it had been previously standing. Considering this, and also that the atmosphere in which the plate was taken out of the bath was saturated with dust, and the state of the interior of the camera in which it was exposed, recollecting, at the same time, that the cloth with which he wiped the glass was taken off the sloppy bench, it is not to be wondered at that the resulting negative was somewhat similar to the first effort of a schoolboy in drawing a portrait over which he subsequently upset his ink. "There, sir," says he, "how do you account for that?" I said at the time, wishing to see if he would go on in the same way, "Well, I scarcely know; try again." Everything was repeated exactly as in the first instance, with this addition—he actually washed his glass in the water which had just washed the hyposulphite of soda off his last picture!

I then told him to get his curtains taken down and dusted, his beams and floor washed out, his dark-room well scrubbed, and a small shelf put up for his developing glass, covered with half-a-dozen thicknesses of blotting-paper, his cloths well washed *without soap*, a few nails put up on which to hang them, one to be kept for cleaning out the slide (or, what is better, some papier Joseph), another for wiping the glasses after washing, and a third for polishing them, strict care being taken that there should be no dust or slop of any kind; and the result was, that he has never had occasion to

write to me since. Now, what holds good with collodion holds good with every other branch; it must be always borne in mind that the greatest care, the strictest cleanliness, and the most undeviating perseverance, are necessary to the successful practice of photography.

And now, then, to return to what I commenced with—the causes of failure in the calotype process.

Causes of Failure.—If the negative in developing assume a disagreeable reddish or foxy brown, the cause, probably, is a deficiency of acetic acid in proportion to the strength of the silver used, or from the presence of nitrate of potash left in the paper; by not washing the iodized papers sufficiently, or from not using a sufficient quantity of water for the removal of the salt named. It may also arise from not using the iodized paper for a considerable period after it has been prepared. It must be noted, that the sooner the iodized paper is used after preparation, the more brilliant and satisfactory the picture will be.

Remedy.—After well washing the negative, when fully developed, and before submitting it to the fixing bath, immerse it in the following solution until the required black tone is acquired. Take

Chloride of gold, 1 drachm.	Hyposulphite of soda, 3 drachms.
Distilled water, ½ pint.	Water, ½ pint.

When dissolved, stir the water, and, stirring all the time, add the chloride of gold solution in small portions at a time. This bath will convert the foxy red colour of the negative into pure black, and it must be afterwards fixed in a solution of four parts water and one part hyposulphite of soda; after which it must be well washed in plenty of water. Perhaps it may be necessary to explain what I mean by well washed. Place your photograph in a shallow dish under a water tap, and turning the tap so that you may have a stream about the diameter of a good-sized quill, allow it to run over your photograph for three or four hours; after which hang up to dry. I should then consider the photograph sufficiently well washed.

Spots and Stains, showing the grain of the flesh in the points of the fingers. These are invariably caused by carelessly allowing the fingers to come in contact with the paper when preparing it, more especially when making it sensitive in the nitrate of silver bath, or in any part of the process when the fingers have been dabbling in hyposulphite of soda previously.

Remedy.—Keep the fingers particularly clean, and never touch the surface of the paper at all; handle it by the corners in every operation.

A Black Uneven Line, running from one corner in the direction of the opposite one. This is caused by the use of a brass pin, for the purpose of pinning up the sheet by one corner; it partly reduces the silver, and the combined solutions running down in the direction of the lowest corner causes the stain.

Remedy.—Carefully wipe your pins, and before you pass them through the papers blot off the corner to be pinned, and double a piece of blotting-paper over the corner before you insert the pin. This is more necessary when using the silver solution than at any other time.

Blackening in the Bath.—The negative will blacken all over in the developing bath. This may be caused by over exposure, but in that case there will be a feeble image of the object on the negative; or it may be caused by light getting entrance to the camera

independent of the lens; or the prepared sheet may have been accidentally exposed to the light previous to development.

Remedy.—Should the universal blackening be caused by accidental light, remedy the defect; if caused by over exposure, expose for a shorter time.

The Negative will become red, or foxy all over. This arises from the want of sufficient acetic acid to regulate the decomposition of the silver salt, and keep it in such a state that it can only be decomposed by light.

Remedy.—Increase the quantity of acetic acid. Acetic acid differs very much in its strength, therefore any quantity mentioned in this treatise means that quantity of glacial acetic acid.

Woolly Appearance.—A woolly rough appearance in the negative, which of course would be worse in the positive; this may arise from too much washing when the paper was iodized—a paper too rough in its texture—using a rough grained blotting-paper after exciting—or using paper that has been iodized for a very long time. It may also occur from want of proper focusing, or the agitation of the camera during exposure from wind, or other causes. As it would be impossible for me to say which of the above would cause this appearance in any particular negative without seeing it, I can only point out the cause of the effect to the reader, leaving it to him to ascertain what the particular cause may be, and then he can easily remedy it himself if he has carefully considered the principles involved.

White or Black Spots, with streaks from them. These are nearly always caused by the most minute particles of iron, copper, or brass, getting into the paper either accidently or from the wear and tear of the machinery used in making it, of course there is no remedy for these but to choose paper quite free from them.

Marblings do not appear until after the first or second preparation of the paper, when spots of irregular form, markings of a dozen shapes, *all* arise from want of care, either in not skimming the surface of the developing or exciting solution, when immersing or lifting negatives into or out of it, or not thoroughly washing and cleaning the dishes or measures used, especially when one dish or measure has to receive two or three solutions, or from not properly cleaning the glass against which the paper is pressed in the paper slide, or from other similar causes.

Remedy.—More care and attention to cleanliness. Let me again impress on the operator the necessity, if possible, of keeping separate dishes and measures for each solution; and even then wash and clean them, as if they had contained solutions of a different nature.

Causes of Failure in the Wax Process.—Almost all the observations made with regard to the calotype relate also to the wax paper process; but the use of *wax* as a preliminary preparation necessitates a few additional observations. In the calotype many of the *causes* of failure—I mean more particularly the woolliness of the negative—cannot be traced to the same causes in the wax paper process; for instance, the washing or blotting off with rough paper, because the first operation in the latter process is to fill the pores or body of the paper with wax; this paper, of course, will stand all the washing and blotting you may wish to give it, as the presence of the wax renders it hard and smooth on its surface. But similar effects may be caused by the adulteration of the wax,—a thing so common that, unless you go to a first-rate establishment (and that *must be* a wax bleacher's), you cannot obtain a pure specimen; even in the last case, you must tell the principal for what purpose you want it; but the wax you will then obtain *will not be white*. The principal substance of adulteration is sperma-

ceti, and the woolliness or roughness is owing to the unequal action of the chemicals on the atoms of wax and spermaceti. Another great cause of unequal action arises from using an iron *too hot*, as in that case it *removes the wax*, and that unequally. These few observations, added to the foregoing, will be quite sufficient. I would have the reader bear in mind that, although the surface of waxed paper is not so easily damaged by washing as the prepared paper, still it will be well to prevent any friction; it is, therefore, better to float or immerse the papers in the different solutions than to use the glass rod; the finest-grained *blotting-paper* should also be used.

PHOTOGRAPHY ON GLASS.

The Albumen Process.—The art is indebted to Sir John Herschel for the adaptation of glass plates to receive sensitized organic substances. In order to determine how far organic matter was indispensable to the discoloration of silver solutions, he prepared a solution of salt, extremely diluted, which he mixed with nitrate of silver, so dilute as to form together a liquid only slightly milky. This was poured on a plate of glass laid horizontally at the bottom of a flat vessel, from which, after several days, the liquid was drawn off by a syphon tube, and the last portion, drop by drop, by a syphon composed of a few fibres of hemp laid parallel, and moistened without twisting. The glass was not touched till quite dry, when it was found coated with a uniform film of chloride of silver, which adhered with considerable tenacity to the glass, but was not sensitive to light. On dropping on it a solution of nitrate of silver, and spreading it over by inclining the plate to and fro, it became highly sensitive. Exposed in this state to the focus of a camera, it became impressed with a remarkably well-defined negative picture. These experiments, communicated through the Journal of the Royal Society, had no doubt their influence on the ardent minds who were then pursuing this wonderful and fascinating art.

Among others who had devoted themselves to the investigation was M. Niepce de St. Victor, the nephew of the discoverer of the Daguerreotype process. This gentleman, as early as 1847, had made considerable progress in developing the albumen process, and seems fairly entitled to the merit of perfecting the idea thrown out by Sir John Herschel. However that may be, from that date the use of glass was rapidly brought to perfection. This process derives its name, our readers need scarcely be told, from the organic substance chiefly used, namely, the white of eggs. Albumen forms one of the constituents of many animal substances; amongst others, and in combination with different fatty matters, it is found in its purest state in the white of an egg.

Mr. J. E. Mayall has entered so very fully into this process in his address to the Photographic Society, that we cannot do better than quote his paper. "Albumen," Mr. Mayall proceeds to say, "is the true starting-point from which all animal tissues are formed, as the egg contains no other nitrogenous compound except albumen; the yolk containing, besides albumen, a yellow fat only. Its chief characteristic is its coagulability by heat. We shall speak of its two conditions,—soluble, or uncoagulated albumen, and insoluble, or coagulated albumen.

"*Soluble Albumen.*—Animal albumen of the soluble kind may be obtained in a solid form by evaporating at a temperature below 120°; it is then a dry, yellowish, horny, and brittle mass.

"This can be powdered, and treated successively with ether and alcohol, which free it from fat, salts, and other foreign matter, until we obtain it pure.

"When thus completely dry it is without taste or odour, and has neither acid nor alkaline reaction.

"In the dry state it may be heated even to the temperature of boiling water, without passing into the insoluble coagulated form. Moistened with water, it swells up, becomes transparent, and by the addition of more water it dissolves into a colourless, tasteless fluid.

"If this solution be heated to a temperature of 140°, it passes into the coagulated form. Less concentrated solutions require a heat of 160°, and very dilute solutions require even boiling before the albumen will coagulate.

"Albumen is insoluble in alcohol and ether. It is soluble to a certain extent in distilled water, but much more easily in water that contains an alkaline salt or chloride of sodium.

"Mulder has given great attention to its analysis. His most recent investigation gives:—

Carbon	53·5
Hydrogen	7·0
Nitrogen	15·5
Oxygen	22·0
Sulphur	1·6
Phosphorus	0·4
	100·0 parts.

"Albumen easily putrefies in the moist state, by the action of the atmospheric agents, for which reason it requires to be used immediately after it is mixed with the chemicals; in winter the time may be prolonged to forty-eight hours, but in summer not longer than six hours.

"The greater number of the metallic salts, according to Lehmann, precipitate albumen, the precipitate containing either a combination of basic salt with albumen, or a mixture of two compounds, one of which consists of the acid of the salt and albumen, and the other of the base of the salt and albumen. The albumen generally passes into the insoluble form.

The precipitated and washed albumen, when dissolved in $\frac{1}{100}$ of caustic potash, and digested for one hour at a temperature of 160°, converts the sulphur and phosphorus into a phosphate and sulphide. The filtered solution, if now treated with acetic acid in slight excess, yields a gelatinous precipitate of protein; which Mulder, its discoverer, designates as the basis of albumen, fibrin, and casein.

"For the object of this inquiry it is sufficient to know, that albumen cannot exist in the soluble state in the absence of mineral constituents; that a slight alkaline reaction is the best condition for photographic operations. The phosphorus which it contains is a most important element of success, while the sulphur does not appear to have any prejudicial effect on the subsequent process with the aceto-nitrate of silver.

"The earnest inquirer is referred to Lehmann's 'Physiological Chemistry,' published by the Cavendish Society; article *Albumen*, vol. i. p. 330; and *Fluids of Eggs*, vol. ii. p. 353; a work that ought to be carefully studied by every chemist who desires to obtain accurate and recent information on this important subject.

"For the photographer's purpose the albumen of the hen's egg is the easiest of

access. The eggs must be fresh, not more than five days old. They ought to be kept in a cool place. Those from the country are better than town-laid eggs, and I advise, where practicable, that the hens should have carbonate and phosphate of lime strewn about for them to peck at. This enriches the albumen and renders it more limpid. Each egg must be broken separately into a shallow cup, and the yolk retained in the shell as well as the germ; then poured into a measure until the required quantity of limpid albumen is obtained.

"To M. Niepce de St. Victor we are indebted for the first application of albumen to photography. In the latter part of 1848 I first saw an imperfect impression of some chimney-pots, at Cha. Chevallier's, optician, Paris; he could not, or would not, tell me how it was done. It was sufficient to know that the thing was possible, to make me attempt it again.

"I shall in this paper confine myself to the negative process, merely remarking, that the only difference between the negative and the positive process consists in substituting the chloride of sodium for the bromide of potassium.

"*Cleaning the Glass.*—New patent plate-glass is the best. Get into the habit of placing the face-side towards the wall, and into the boxes with the face towards the left hand. Solution:—Alcohol, 30 grammes (450 grains); strong liquid ammonia 10 grammes (150 grains); water, 40 grammes (600 grains); tripoli, 30 grammes (450 grains). Shake up to mix.

"Tie up three pieces of clean cotton wool in round balls, each about the size of a small hen's-egg; then fix the glass firmly in a wooden screw-vice perfectly flat; with a piece of cotton and the above solution rub hard and evenly the surface of the glass, in a similar manner as for Daguerreotype plates; then more gently; rear it up to dry. Take another glass, which rub in the same manner, and so on for twelve dozen. Change the ends to dry the upper edge of the glass. When dry, wipe the edges, as also the back, slightly with another ball of cotton, without touching the surface to free it from dust. Rub off the surface with a clean ball of cotton, firmly at first, then softly and evenly; then, with a clean hog's-hair brush, dust the back and edges, and, put the glass into a dry clean box, face towards the left hand. My boxes hold fifty plates each. The plate must be albuminized the same day; if left, it will be necessary to clean them again. This plan of cleaning is both for negative and positive glass.

"*Spreading on the Plate.*—For twelve dozen plates the albumen should be prepared as follows:—Take 450 fluid grammes (about 12 ounces) of albumen; 7½ fluid ditto (112 grains) saturated solution iodide of potassium; 1½ ditto (23 grains) bromide of potassium; 1 drop of solution of caustic potash; 1 gramme (15 grains) of water.

"The iodide and bromide of potassium ought to be each a saturated solution in distilled water, at a temperature of 60°, and weighed in a cup carefully balanced. The utmost care is necessary to observe these proportions; if too much of the salts be used, they crystallize in the albumen and make spots; the drop of caustic potash renders the albumen more limpid; pour the above ingredients into a wide-mouthed and rather large bottle (say half-gallon), shake up until the bottle is completely filled with white foam. This will take ten minutes. Let it stand six hours in a cool place; then pour off the clear albumen into a tall glass measure that does not taper towards the bottom, but rather, like a decanting vessel, broader at the bottom, to allow any particles of germ to fall down and not stick to the sides. The solution should be poured into this vessel one hour before it is required.

"It is now necessary to avoid most carefully the formation of air-bubbles, which,

in the act of spreading, deteriorate the impression by making streaks; these are caused by the partial drying and decomposition of the chemicals in the albumen.

"I have found the following the most effectual way to avoid these faults. I have a glass funnel with a long beak that just reaches to the bottom of my glass pint-measure, upon which funnel I place a flat plate of glass turned up at the edges, with a hole in the centre; the whole is lined with moistened muslin, so that when the albumen falls on to the glass dish, in the act of pouring, it glides gently down into the measure placed under. The funnel is supported by a convenient wooden stand, termed in the laboratory a filter support.

"I place a wet sponge—also covered with clean muslin—on a table near at hand, between the above arrangement and the drying-box.

"Let us suppose then that the dish is ready, the drying-box placed perfectly level, the plates of glass all clean, a soft flat camel's-hair brush well dried and at hand. I take a glass, balanced on the tips of the fingers of the left hand, brush off the dust, and from the measure of albumen pour on to the surface sufficient to well cover the plate; keeping it as level as possible, then suddenly turn it down on its edge, to allow the excess of albumen to run into the glass dish; wiping it carefully for eight seconds on the edge of the muslin, then again eight seconds on the sponge cushion, and placing it in the drying-box. A few trials will give the exact moment necessary to deposit sufficient albumen on the surface; if too much remains, the plate will be streaked and uneven; if too little, the proof will be thin and weak. Continue spreading till the drying-box is full. The French albumen drying-boxes are the only ones I can use, and I therefore recommend them. Each board should be tried with a spirit-level. The plates will be perfectly dry in three days; put them into boxes in a dry place, where they will keep for any length of time, though it is best not to prepare more than one month's supply beforehand; four dozen plates can be coated in an hour.

"*To Iodize the Plates.*—As before stated, an alkaline reaction is the best condition for spreading the albumen, as it renders it more limpid; but this alkalinity is detrimental to the silvering process (an acid reaction now being of equal importance). The plates have, therefore, to be passed over the vapour of iodine, just like a Daguerreotype plate, to completely saturate the alkaline reaction; this will take from two to four minutes, according to the temperature; the albumen surface ought to have a yellow tinge, by the vapour of iodine; this operation ought to be done a few hours before silvering.

"*Silvering the Plates.*—The process of silvering is performed as follows:—Take 1,500 grammes (50 ounces) of water, 150 grammes (about 4 ounces) of nitrate of silver, and 150 grammes (about 4 ounces) of glacial acetic acid. Filter; use gutta-percha baths as for collodion. I use two baths and a bath of distilled water, and so arrange the dipping that each plate remains in the bath one minute and a-half. I then put each plate in succession into the bath of distilled water, washing the back with common, and the face with distilled, water; rearing up to dry in a place free from dust.

"This operation is quite mechanical, and much easier to do than to describe. At first the operator is afraid to run sufficient water on the plate to wash it; but he need have no fear, as the iodo-bromide of silver is precipitated into the substance of the albumen and cannot be washed out. The washing serves to make the operation more certain.

"Renew the silver bath as follows:—For every 100 plates add thirty grammes (450

grains) of nitrate of silver, twenty grammes (300 grains) of glacial acetic acid, and water to make up the original quantity.

"*To Prepare the Plates.*—In preparing the plates for the camera, pass them over the vapour of iodine half a minute previous to placing them in the camera slide; expose in the camera from thirty seconds to ten minutes, according to the intensity of the light, the colour of the object, and the aperture of the camera; if required to be very quick, the plate should be plunged into a dilute bath of gallic acid—one of acid to ten of water. This last suggestion is made for plates to be used immediately.

"*To Develop the Image.*—In order to develop the latent image, use (B) a saturated solution of gallic acid. (C) 400 grammes (13 ounces) of water, thirty grammes (450 grains) of nitrate of silver, and eighty grammes (3 ounces) of acetic acid. (D), a pint bottle filled with three parts of gallic acid solution and one part water. Pour into a dish, kept expressly for this purpose, about half an inch of liquid in depth, drop into it eight drops of solution (C), shake it up; then run distilled water on to the plate just taken from the camera, and plunge it into the gallic acid (D) as above prepared; shake it about, fill the dish with plates, and continue to shake up, adding every hour eight to twenty drops of solution (C), until the image is fully developed. The operation may be continued with safety for three days if necessary, though it is best to complete the developing in twelve to sixteen hours. Wash well with water, rear it up to dry.

"Another and quicker method of developing is with the pyrogallic acid:—300 grammes (9 ounces) of water, one gramme (15 grains) of pyrogallic acid, five grammes (75 grains) of glacial acetic acid, and one gramme (15 grains) of formic acid. The plates will develop in half an hour in this solution, and in warm weather in less time; but I find the half-tones are not so well preserved as in the slow process.

"*Fixing.*—The fixing is performed as follows:—100 water, ten hyposulphite of soda. Continue the fixing till all the yellow iodide disappears; wash well—dry—and the plate is finished.

"The hyposulphite solution should be kept entirely apart from the albuminizing; in fact, it should not be in the same room.

"The positive plates are prepared in the same way, only substituting chloride of sodium for the bromide of potassium. The exposure by superposition ought to be in north light ten seconds to one minute and a-half, according to the intensity of the negative proof.

"I find collodion negatives print much quicker than albumen negatives; collodion is more transparent.

"I recommend the glass to be an inch larger each way than the desired view, to allow for marginal error.

"Also always, if possible, to use new glass, as I find that which has been already used is uncertain.

"I have taken one hundred plates, prepared as above directed, without having a single failure. In fact, each plate receives precisely the same treatment, and if the directions are strictly followed, failure is almost impossible.

"Should the operator be compelled to use his glasses over again, I recommend that the albumen surface be washed off with caustic potash, and a scratch made with a diamond on the albumen side, so as to use the other; then wash the glass plates with common water, then with nitric acid and cotton, then much water again, then warm water, and rear up to dry, after which, clean as for new glass.

"The solutions must be carefully corked up to avoid evaporation, the gallic acid bottles kept full, the room free from dust, and dark thick yellow curtains to exclude the actinic rays. The plates will keep excited for fourteen days, and may be developed six days after the view is taken, which, to many photographers, may be an advantage.

"Never allow a sulphur match to be lighted in the albumen room; avoid vulcanised india-rubber rings, the sulphur from which produces spots; wash the developing dishes every time they are used with nitric acid, and much water afterwards; wash the silver baths with distilled water, and then turn them upside down to avoid dust.

"I recommend French weights and measures: the gramme weight is 15·43 grains (nearly 15½), the fluid ounce is equal to 31 grammes."

Mr. Negretti's Albumen Process.—After some directions for selecting and cleaning the plate of glass, the writer proceeds as follows:—

"*The Albumen.*—The manner of making albumen is very simple. You provide a rather large basin—I would recommend a Berlin evaporating basin with a small lip; you then procure a wooden fork, which is to be bought at most fancy bazaars; but a silver one is as good. Now get some good large eggs, all of a size, if possible. We reckon a large egg to contain thirty grammes (very nearly an ounce) of albumen, and we very seldom make more than 300 grammes (or 10 ounces) of albumen at a time, for which purpose we employ ten eggs. We always prefer having, or making, it fresh. Break the eggs one by one on the edge of a cup, and separate the yolk from the albumen, using the shells themselves for the purpose. Care must be taken not to leave any of the germ in the albumen. Throw the produce of one egg into the basin, and then break all the others one by one on the edge of the cup, after each operation emptying it into the basin. Into the albumen put one per cent. of iodide of ammonium or potassium, and twenty per cent. of distilled water. I mostly mix the iodide and distilled water in a glass vessel graduated into grammes, previous to putting it into the albumen; but either plan will answer. Now with the fork you beat the albumen into a thick froth. This will take about a quarter of an hour. The froth must be so thick and hard, that a piece may be pulled up bodily with a fork stuck into it. We prefer using iodide of ammonium, for we have found that iodide of potassium has sometimes caused the blacks in our negatives to become full of minute holes. The albumen having been beaten a sufficient time, cover the basin with a clean sheet of paper and put it away somewhere out of the dust. Many persons decant the albumen off from the basin, but I prefer using it out of the basin itself, because the albumen, after it has subsided, leaves a thick crust on the top, and in order to pour it on the plate it has to force itself through this crust, consequently it filters itself at the same time.

"*The Drying Box.*—The box for drying the plates must be well made, with a number of grooves running parallel to each other, and the exact width of your glasses. In each alternate groove there is a board, made so as not to twist easily by being heated, and sliding freely in the grooves; the box must also have an arrangement for rendering it perfectly level. This box, previous to its being used, must be well dusted inside; the boards also must be well cleaned, and each well dried and heated—if in summer, in the sun, or in winter before a fire. If your box and boards are not thoroughly desiccated and rendered absorbent, your plates will not dry easily. Having now your box, glasses, and albumen ready, carry all these things *at once* into your albuminizing room. I say, at once, for if you go in and out of the room you will create such a dust that it will not be possible for you to cover the plates nicely and cleanly.

"The room should be prepared some two or three hours before you want to use it; and it should be well watered and swept, and if there are any shelves, or other places likely to harbour dust, they should be well wiped with a wet sponge; for it must be borne in mind that dust is your great enemy in the albumen process.

"*Plate-holder.*—To albuminize the glasses you must provide a plate-holder. The one I recommend is a round stick, about half an inch in diameter, and eight or nine inches long, tapering at one end; it has at the other end a small cup, about one inch or more in diameter. Round the edge of the cup, which is about a quarter of an inch thick, is melted some gutta-percha. This makes the best holder I have yet tried.

"*Spreading the Albumen.*—Now get a sheet of clean paper, and spread it on a table before you; also light a spirit-lamp, and have a small glass rod and a fine camel's-hair pencil on the same table, taking one of the glasses, which should be marked with a small adhesive label to indicate the side you do not intend to albuminize. Place this glass with its best side flat on the sheet of paper; then take the plate-holder and warm the gutta-percha gently over the spirit-lamp. Upon placing the warm part on the back of the glass, you will find that in a few seconds you will be enabled to lift the glass, and handle it, or turn it as you wish. The albumen is now poured upon the glass; should it not spread evenly, the little glass rod will enable you to guide the albumen wherever you like. The albumen is allowed to drain off first at one corner and then at the other. Turning it over, allow it to descend to the bottom, and that will be the second time the albumen has gone over the glass. It is then turned back again, and allowed to go half way. At this stage a rotatory motion is imparted to the glass by means of the holder, which is continued for about seven or eight seconds; then the holder is taken hold of close under the glass and the plate forced off the gutta-percha. The glass is now placed in one of the grooves of the drying-box, which is shut close until you are ready with the next plate. Of course, the operation must not take so long a time to perform as I have taken to describe it. The small camel's-hair pencil serves to pick off any dust that might accidentally fall on the plate during the time you are spreading the albumen; draw the pencil between your lips and use the point thus made for that purpose. After remaining in the drying-box a few hours, your plates will be hard enough for the next operation, which is—

"*Making the Plates Sensitive.*—The bath we use for this purpose is a horizontal one; it is a flat dish made with a piece of plate-glass, having tight wooden sides like a shallow box, the plate-glass forming a nice flat bottom. The dish should be about one-third longer than your plates. The solution is composed of distilled water, nitrate of silver, and glacial acetic acid, in the proportion of ten of nitrate of silver and ten of acetic acid to every hundred of water. The quantity required is, of course, according to the size of your plate. This solution is to be poured, say a quarter of an inch deep, into the dish, one end of which is raised as much as you can without spilling the solution; the albuminized plate is then placed face upwards in the upper or empty part of the dish; then, by a little dexterous movement, you suddenly, by bringing the dish level, cause the solution to flow quickly and evenly over the plate, which is left in the bath about forty seconds. It is as well to raise the plate up several times, and otherwise agitate the bath; for this purpose you use a small piece of silver wire flattened and bent at right angles at one end. The flat part is inserted between the glass and the dish, and the plate lifted by it. You must be very particular in rendering your plate sensitive, for if you do not get your solution quickly and evenly over the plate, you will have a sharp and clear outline wherever you have stopped, precisely as

if the negative had been cracked. The plate is now taken out of the bath, and will present a nice light-blue tint. It is immediately well washed with distilled or rain water, and must be washed back and front, especial care being taken that not any of the aceto-nitrate is left on the plate, or your picture will at that spot turn black. The water must flow evenly over the plate, and no greasy streaks be perceptible; until that takes place, your plate is not washed enough. The plate is now placed in a large box having some blotting-paper at the bottom to facilitate draining, and is then ready for use.

"*Exposure in the Camera.*—If your object is near, your plate will be more sensitive if used wet at once; but for keeping, it is best to let the water dry off previously to the plate being placed in the slide.

"The time of exposure depends of course on the light, the object you have to take, and on the focal length of your lens; but in summer we have taken a good negative with ten minutes' exposure. In France or in Italy good albumen negatives are taken in three or four minutes. A little practice, however, will soon determine the proper time of exposure required.

"*Developing the Image.*—I take a saturated solution of gallic acid, and a solution of nitrate of silver of two per cent., viz., two grammes (31 grains) of nitrate to one hundred of distilled water. I get a nice soft brush or pencil, with hair about three-quarters or one inch long. After placing the plate on a level developing stand, I warm my gallic acid to a temperature of about 80° Fah., and pour on the plate enough to cover it, using the brush to spread it over the plate rapidly (you need not have the least fear in using the brush, for it will almost require a knife to injure the albumen). After allowing the gallic acid to remain about one or two minutes, I pour part of it off, and add to it some of the nitrate solution, the brush being instantly at work in mixing the two solutions together, forming a gallo-nitrate. The mixing on the plate must be instantaneous; in fact, I usually pour the nitrate on the brush, which I rest on the plate. My picture begins now to appear. Should I find, after a little time, that the image does not show itself, which would be the case if the plate were under-exposed, I throw off this solution, and begin again with the warm gallic acid, adding nitrate solution, repeating the operation again and again, until my picture is fully developed. By these means, and by repeatedly re-changing the bath, you are enabled to coax into a very good picture a plate that you have not been enabled to expose sufficiently, either by reason of some one having accidentally moved your camera, or by your being obliged to leave the spot, and which would thus, in any other process, have been a failure.

"The same rule holds good, if, whilst developing, you find you have not sufficient time to finish your picture. You have merely to well wash off the solutions, put the plate away in the dark, and you can resume the development at your leisure, a week after if you wish.

"We do not always succeed in developing our pictures so quickly, but by attention and care negatives should never take more than from half-an-hour to three-quarters; it is not imperative to warm the gallic acid, but by so doing you greatly accelerate the development. The picture is now washed and ready for

"*Fixing.*—This is done with hyposulphite of soda, just in the same way as in fixing a collodion negative; but no cyanide must be used, for that will take off your albumen.

"Positive pictures on glass are generally printed on plates extra thinly albuminized for the purpose, which is effected simply by rotating the plate more rapidly and for a longer time. These also must be developed as quickly as possible; but do not be

tempted to use stronger nitrate solution for that purpose, or you will spoil your pictures. The great fault of the albumen positives I have seen produced in England is, that it has evidently taken such a long time to develop them that they have looked opaque, like bad Daguerreotypes, having a metallic deposit on them which is disgreeable to the eye, and which renders them anything but transparent."

There is a modification of the albumen process much used in America, and I believe with good results—it is called "Whipple's Albumen Process," having been introduced by Mr. Whipple of Boston, a gentleman well known in the photographic world.

Mix in the usual manner:—Albumen, eight ounces; honey, seven ounces; iodide of potassium, three drachms; bromide of ditto, twenty grains; chloride of soda, nine grains.

For foliage, increase the bromide of potassium up to fifty grains.

This mixture is poured on the glass plate in the same manner as collodion, and then dried over a spirit-lamp. The plate is then immersed for ten to twenty seconds only in the following bath:—

Nitrate of silver, one and a-half ounces; water, sixteen ounces; acetic acid, four ounces.

After the dipping, the plate must be well washed, and if all the free silver is washed off, the plates will keep for four weeks. Develop with a saturated solution of gallic acid and nitrate of silver, and fix in the usual manner with hyposulphite of soda.

Collodion Process.—Collodion as a photographic medium is, without doubt, far before any other. The beauty of the details obtained in good pictures taken by this process, the exceeding sensibility of the medium itself, and the comparative ease of its manipulation, place it at the head of *all* photographic agents. I shall, therefore, go into this branch of the art as fully as possible, preferring rather to say too much than too little.

Mr. Archer, who was the first, in conjunction with Mr. Fry, to introduce this important addition to the art, deserves our utmost thanks for enabling us to obtain effects so utterly impossible to be obtained by any other means. Some idea of the value of the discovery may be formed from the fact, that instantaneous pictures have been taking by Mr. Fenton, of clouds, waves, shipping, animals, figures, &c., by a single lens. On one occasion, where a man was running, the leg that was on the ground when the lens was uncovered was perfectly defined, while the other left three or four impressions in its transit during the moment of exposure.

Choice of Glass.—This may be classed under five heads:—Cleaning the plates, coating with collodio-iodide of silver, exposure in the camera, developing the image, fixing the image; but first a few words on the choice of the glass. Here we can follow no more faithful guide than Mr. Hardwich:—

"Much care should be taken in the selection of glass intended to be used for photographic purposes. The ordinary window-glass is often inferior, having scratches upon the surface, each of which causes an irregular action of the developing fluid. Also the squares are seldom perfectly flat, so that they do not touch the slide at every point, and hence a part of the image is out of focus. A more serious inconvenience, arising from want of flatness, is, that the plates are apt to be broken in compression during the printing process.

"The patent plate answers perhaps better than any other description of glass, but if that cannot be procured the 'flatted crown' may be substituted.

"*Cleaning the Plates.*—Before proceeding to wash the glasses, each square should be

roughened on the edges by means of a file or a sheet of emery-paper. If this precaution be omitted, not only are the fingers liable to injury, but the collodion film is apt to contract and separate from the sides.

"In the process of cleaning the glasses, it is not sufficient—as a general rule—to wash them simply with water; other liquids are required to remove grease, if any is present. For this purpose, perhaps, caustic potash, sold in druggists' shops under the name of 'liquor potassæ,' is as good as any; or, if that is not at hand, a warm solution of common 'washing soda,' which is carbonate of soda.

"Liquor potassæ, being a very caustic and alkaline liquid, requires care in the handling; it softens the skin, and dissolves it away even more so than acids. A safe plan of proceeding is to dilute the potash with about four parts of water, and to apply it to the glass by means of a cylindrical roll of flannel; after wetting both sides of the glass thoroughly, allow it to stand for a time until several have been treated in the same way; afterwards wash well with water and rub dry in a cloth.

"The cloths used for cleaning glasses should be kept expressly for that purpose; they are best made of a material sold as 'fine diaper,' and very free from flocculi and loosely adhering fibres. They are not to be washed in soap and water, but always in pure water or in water containing a little carbonate of soda.

"After wiping the glass carefully, complete the process by polishing with an old silk handkerchief, avoiding contact with the skin of the hand. Some object to silk, as tending to render the glass electrical, and so to attract particles of dust, but in practice no inconvenience will be experienced from this source. Before deciding that the glass is perfectly clean, never omit to hold it in an angular position and to breathe upon it.

"The use of an alkaline solution is usually sufficient to clean the glass, but occasionally we meet with plates dotted on the surface with small white specks, which are not removed by the potash. These specks consist frequently of hard particles of carbonate of lime; and when that is the case they dissolve very readily in dilute sulphuric acid, in about four parts of water, applied by means of a roll of flannel. Nitric acid, also diluted in four parts water, also answers the same purpose; but it destroys any dress it comes in contact with, unless it is at once treated with liquor ammonia or some other alkali."

Some operators employ cyanide of potassium, and others ammonia, in cleaning the plates. A mixture of Tripoli powder and spirits of wine is preferred by those who fear injuring the skin by the use of alkalies and acids.

When positives are to be taken, it is advisable to use additional care in preparing the glass, and especially so with the pale, transparent film and neutral nitrate bath.

After a glass has once been coated with collodion, it is not necessary in cleaning a second time to use anything but pure water; but if the film has been allowed to harden and dry upon the glass, possibly the dilute oil of vitriol, or cyanide of potassium, may be required to remove stains.

If, under similar circumstances, a greasiness is perceived, which prevents the plate from being wetted evenly by a stream of water poured upon it, it may be removed by a second application of alkaline liquid.

The Collodion.—Of the collodion itself, no better instructor can be followed than Mr. Edward Ash Hadow, whose address to the Photographic Society we cannot do better than quote:—

"Having," says that gentleman, "experienced some difficulty in producing at all times a collodion of uniform sensitiveness, tenacity, and fluidity, although making use

of the same materials for its preparation, and this as I find being the complaint of many others, it has been my study lately to determine the variations in quality to which the ingredients are liable, and the effects of those variations on the sensitive film; and likewise to ascertain whether the qualities depend on the materials in ordinary use, or on some substances accidentally or intentionally added. Researches on the preparation of collodion may appear superfluous, now that it is supplied of the best quality by so many makers; but as some persons of an independent turn of mind still prefer manufacturing their own, I venture to bring forward the subject with the hope of assisting them. In this beautiful process success depends so much on the quality of the collodion, that, when in possession of a good specimen, it becomes one of the easiest and most simple, and ought to be the most certain of all the processes; for no material, such as paper, of uncertain composition is introduced, we have nothing to fear from plaster of Paris, alumina, or specks of iron or copper, which continually endanger or modify the calotype process; each ingredient can and ought to be obtained in a state of perfect purity, and with this knowledge the degree of success depends upon the skill of the operator himself.

"Of all the substances used in this process, the gun-cotton is usually the only one actually prepared by the operator himself; in this case he cannot fail to have observed the great variations in solubility, and, when dissolved, in the transparency and tenacity of the films, to which it is liable; the various processes also that are given appear at first sight unaccountably different, some directing ten minutes', others a few seconds' immersion. I have examined into the cause of these variations, with a view to obtain certainty, and have also endeavoured to discover how far they affect the sensitiveness of the prepared surface. If we take a mixture of the strongest nitric and sulphuric acids, and immerse as much cotton as can be wetted, after some minutes squeeze out the acid as far as possible, then immerse a second portion of cotton, and again express the acids for a third portion of cotton, and so on until the liquid is exhausted, we shall find, on comparing the cottons thus treated, after washing and drying them, that there is a gradual alteration in their properties, the first being highly and perfectly explosive, and each succeeding portion less so, until the portion last immersed will be found hardly explosive at all, leaving distinct traces of charcoal or soot when burned.

"This may not appear surprising at first sight, as it may be imagined that the latter portions are only a mixture of gun-cotton and common cotton; this, however, is not the case, for if each quantity be immersed sufficiently long, it will not contain a fibre of common cotton, and may yet become charred on burning like unaltered cotton. The most remarkable difference, however, is discovered on treating them with ether containing a little alcohol, when, contrary to what might have been anticipated, the first or strongest gun-cotton remains quite untouched, while the latter portions dissolve with the utmost ease, without leaving a trace behind; this alone is a sufficient proof that no unaltered cotton remains. This difference in properties is owing to the gradual weakening of the acid mixture, in consequence of the nitric acid being removed by the cotton, with which it becomes intimately combined, at the same time that the latter gives out a proportionate quantity of water.

"In consequence of these experiments, a great many mixtures of these acids were prepared of various strengths, each being accurately known, both to determine whether there were more than one kind of soluble gun-cotton; and, if there were, to ascertain exactly the mixture required to produce that most suitable to photographic purposes. By this means, and by, what I believe has not been pointed out, varying the tempera-

ture, at least five varieties were obtained:—First, gun-cotton properly so called, as before stated, quite insoluble in any mixture of alcohol and sulphuric ether. Secondly, an explosive cotton, likewise insoluble, but differing chemically from the first, obtained by a mixture of certain strength when used cold. If warm, however, either from the heat produced spontaneously on mixing the two acids, or by raising the temperature artificially to about 130°, the cotton then immersed becomes perfectly soluble, producing a third variety; if, however, it be thoroughly dried it becomes in a great measure insoluble. The fourth is obtained by the use of weaker acids used cold, and the fifth when the mixture has been warmed to 130° previous to the immersion of the cotton; in either of the last two cases the product is perfectly soluble, but there is a remarkable difference between their properties, for on dissolving six grains of each in one ounce of ether, the cotton treated with warm acids gives a perfectly fluid solution (which is likewise the case with the third variety produced by acids somewhat stronger), while that obtained by the use of cold acids makes a mixture as thick as castor-oil.

"Having obtained these more strongly-marked varieties, as well as intermediate kinds with all gradations of solubility, it was necessary, before I could select any particular formula for preparing the cotton, to compare their photographic properties, with especial reference to sensitiveness, opacity of the reduced silver in negatives, and its colour in positives. A certain weight of each being dissolved in a portion of the same mixture of alcohol and ether previously iodized, the comparison was made, by taking the same objects with each collodion in succession, and likewise by pouring two samples on the same plate of glass, and thus exposing them in the camera together side by side. This last proved to be much the most satisfactory plan, and was repeated many times for each sample, taking care to reverse the order in which they were poured on, that there might be no mistake arising from the difference of time elapsing between the pouring on of the collodion and its immersion in the sensitive bath. By these experiments I had confidently hoped to have solved the question as to the cause of difference in sensitiveness and other photographic properties of collodion; but in this I was disappointed, for, after repeated experiments, I believe I may safely affirm that they are precisely similar as regards their photographic properties. The same, I believe, may be said of Swedish paper collodion, judging from a few comparative experiments I have made, and indeed it is difficult to discover what is the superiority of this material over clean cotton-wool. The ease of manipulation, which some allege, is a matter of taste; but I should decidedly prefer the open texture of cotton to that of a substance like filtering paper, composed of a mass of compacted fibres, the innermost of which are only reached when the acids have undergone a certain degree of weakening by the water abstracted from the outer fibres; and when we consider that from cotton alone we have the means of preparing all varieties of collodion, from the most powerfully contracting and transparent to the weakest and most opaque, and each if required with equal and perfect certainty, there appears to be choice enough without resorting to another material, differing only in being more rare and more difficult to procure. But although the photographic properties of these varieties of collodion-wool are so similar, other circumstances, such as fluidity, tenacity, and transparency, render its preparation of some importance, and indicate that the acid mixture should always be used warm; and it is chiefly in consequence of this very circumstance, that greater success attends the use of nitrate of potash and sulphuric acid than that of mixed acids; for the former when mixed produce the required temperature, and must be used while warm, since on

cooling the mixture becomes solid, whereas acids when mixed do not usually produce so high a temperature, and being fluid can be used at any subsequent period. Another obstacle to their use is the great uncertainty of the strength of the nitric acid found in the shops, requiring a variation in the amount of sulphuric acid to be added, which would have to be determined by calculation or many troublesome trials. When a proper mixture is obtained, the time of immersion is of no importance, provided it be not too short, and the temperature be maintained at about 120° or 130°; ten minutes is generally sufficient (though ten hours would not render the cotton less soluble, as is sometimes asserted).

"In using the mixed acids, the limits are the nitric acid being too strong, in which case the product is insoluble, or too weak, when the cotton becomes immediately matted, or even dissolved if the mixture is warm. I have availed myself of these facts in order to produce collodion wool by the use of acids, without the trouble of calculating the proper mixture according to their strength. Five parts by measure of sulphuric acid, and four of nitric acid of specific gravity not lower than 1·4, are mixed in an earthenware or thin glass vessel capable of standing heat; small portions of water are added gradually (by half drachms at a time, supposing two ounces to have been mixed), testing after each addition by the immersion of a small portion of cotton; the addition of water is continued until a fresh piece of cotton is found to contract and dissolve on immersing; when this takes place, add half the quantity of sulphuric acid previously used, and (if the temperature does not exceed 130°, in which case it must be allowed to cool to that point) immerse as much cotton, well pulled out, as can be easily and perfectly soaked; it is to be left in for ten minutes, taking care the mixture does not become cold; it is then transferred to cold water and thoroughly washed. This is a matter of much importance, and should be performed at first by changing the water many times, until it ceases to taste acid, treating it then with boiling rain-water until the colour of blue litmus remains unchanged; the freedom from all trace of acid is insured by adding a little ammonia before the last washing. Cotton thus prepared should dissolve perfectly and instantaneously in ether containing a little alcohol, without leaving a fibre behind, and the film it produces be of the greatest strength and transparency, being what M. Gaudin terms 'rich in gun-cotton.' The mixture of nitrate of potash and sulphuric acid is defective chiefly from the want of fluidity, in consequence of which the cotton is less perfectly acted on; this may be remedied by increasing the amount of sulphuric acid, at the same time adding a little water. A mixture of five parts of dried nitre, with ten of sulphuric acid, by weight, together with one of water, produces a much better collodion wool than the ordinary mixture of one of nitre with one and a-half of sulphuric acid. The nitre is dried before weighing, in order that its amount, as well as that of the water contained in the mixture, may be definite in quantity; it is then finely powdered, mixed with the water, and the sulphuric acid added; the cotton is immersed while the mixture is hot, and afterwards washed with greater care even than is required when pure acids are used, on account of the difficulty of getting rid of all the bisulphate of potash that adheres to the fibres, which both acts as an acid and likewise causes the collodion to appear opalescent when held up to the light—whereas the solution should be perfectly transparent.

"Having obtained good collodion wool, the next point of inquiry was with regard to the solvent: to ascertain whether the addition of alcohol beyond what is absolutely necessary to cause the solution of the gun-cotton in ether, was beneficial or otherwise.

For this purpose ether and alcohol were prepared perfectly pure, and mixtures were made of one of alcohol to seven of ether, two to six, three to five, four to four, and five to three. In one ounce of each were dissolved six grains of gun-cotton and four grains of iodide of ammonium (iodide of potassium could not be employed, since it requires a certain amount, both of water and alcohol, to keep it in solution); they were then compared, using a thirty-five grain solution of nitrate of silver, both by pouring on separate glasses, and likewise by covering two halves of a plate with two samples, as in examining the gun-cottons, thus placing them under the same circumstances during the same time; in this way the effect of adding alcohol was very clearly perceived, since the differences between the collodions was much greater than could have been anticipated. The first mixture containing only one-eighth of alcohol was quite unfit for photographic purposes, it being almost impossible, even with the most rapid immersion, to obtain a film of uniform sensitiveness and opacity throughout, the surface generally exhibiting nearly transparent bands, having an iridescent appearance by reflected light. The second mixture, with one-fourth of alcohol, is liable to great uncertainty, for if there be any delay in pouring off the collodion, the same appearances are seen as in the first, and, like it, the surface is very insensitive to light, while, if the plate be rapidly plunged in the bath, the collodion film becomes much more opaque than before, and is then very sensitive. The third proportion of three of alcohol to five of ether, is decidedly the best, giving without the least difficulty a film beautifully uniform and highly sensitive, at the same time perfectly tough and easily removable from the glass if required. A further addition of alcohol, as in the last two collodions, was not attended with any corresponding advantage or increase of sensitiveness; on the contrary, the large proportion of alcohol rendered them less fluid, though with a smaller quantity of gun-cotton they would produce very good collodions, capable of giving firm films. The cause of the weakness of the film observed on adding much of the ordinary alcohol is the large amount of water it usually contains.

"This surprising improvement, caused by the addition of a certain quantity of alcohol, is referable to causes partly chemical, partly mechanical, for on examining the films it will be found in the first, and occasionally in the second collodion, that the iodide of silver is formed on the surface, and can be removed entirely by friction without destroying the transparent collodion film below, while in those collodions that contain more than one-fourth of alcohol, the iodide of silver is wholly in the substance, and in this state possesses the utmost sensitiveness. This difference of condition is owing to the very sparing solubility of ether in water, which in the first case prevents the entrance of the nitrate of silver into the film, consequently the iodide and silver solutions meet on the surface; but on the addition of alcohol, its solubility enables the two to interchange places, and thus the iodide of silver is precipitated throughout the substance in a state of the utmost division.

"This difference is clearly seen under the microscope, the precipitate being clotted in the one case, while in the other the particles are hardly discoverable from their fineness. The presence of a little water considerably modifies these results, since it in some degree supplies the place of alcohol, and is so far useful; but in other respects it is injurious, for accumulating in quantity, if the collodion is often used, it makes the film weak and gelatinous, and what is worse, full of minute cracks on drying, which is never the case when pure ether and alcohol are used. Since the ether of the shops almost always contains alcohol, and frequently water, it is important to ascertain their amount before employing it for the preparation of collodion. The quantity of alcohol

may be easily ascertained by agitating the ether in a graduated measure glass (a minim glass does very well) with half its bulk of a saturated solution of chloride of calcium. This should be poured in first, its height noticed, and the ether poured on its surface, the thumb then placed on the top, and the two agitated together; when separated, the increase of bulk acquired by the chloride of calcium indicates the quantity of alcohol present, and for this, allowance should be made in the addition of alcohol to the collodion afterwards. Water is readily detected, either in ether or alcohol, by allowing a drop to fall into spirit of turpentine, with which they ought to mix without turbidity; this is immediately produced if they contain water. For detecting water in alcohol, benzole is a more delicate reagent than spirit of turpentine (Chemist, xxix. 203). It is also necessary that ether should be free from a remarkable property it acquires by long keeping, of decomposing iodides and setting free iodine, which thus gives the collodion a brown colour. The same property may be developed in any ether, as Schönbein discovered, by introducing a red-hot wire into the vapour in the upper portion of a bottle containing a little ether and water; if it be then shaken up and a solution of an iodide poured in, the whole rapidly becomes brown. This reaction is very remarkable and difficult to explain, for even a mixture of ether and nitric acid fails to produce a colour immediately. Ether thus affected can only be deprived of this property by rectification with caustic potash.

"*Iodised Collodion.*—I have now a few remarks to offer on the modes of iodizing or rendering the film capable of becoming sensitive, by the addition of some soluble iodide. Those that have been recommended are chiefly the iodides of potassium, ammonium, cadmium, and zinc: of these the last three have the great advantage of being readily soluble in any collodion, and may therefore be added at once to the solution of gun-cotton; but iodide of potassium requires a little water, and even then, if added to collodion without having been previously dissolved in some of the alcohol, will be found to dissolve but very slowly.

"In preparing collodion with this salt, four grains were dissolved in three drachms of strong alcohol, and ether was added to make up the ounce. I found that the first two and a-half drachms of ether began to precipitate the iodide, and after addition of the five drachms required, a dense deposit had formed, which was not re-dissolved until twelve drops of water had been added. This I merely mention to show that there must be a little water in the mixture, although in using ordinary ether and alcohol this might not be perceived. Before comparing collodion prepared with different iodides, it appeared probable that those of potassium and ammonium would produce greater sensitiveness than those of zinc and cadmium; for this reason, that the nitrates of ammonia and potash, which are produced together with iodide of silver, on immersing films prepared with the first two iodides in the nitrate bath, are perfectly neutral, while the nitrates of zinc and cadmium, which result when collodions containing those metals are used, have a feebly acid reaction on litmus paper, and thus by their presence in the film might, like weak acids, retard the action of light. In actual experiment, however, I did not find this to be the case, for when carefully and similarly prepared with equivalent quantities of each iodide, and used while colourless, the collodions appear similar in sensitiveness, gradation of tints, and all other respects. In a few days, however, they begin to differ in consequence of partial decomposition and liberation of free iodine, which occurs more readily with the iodides of ammonium and zinc than with potassium, while the iodide of cadmium, if I may conclude from one sample I have by me, remains perfectly colourless for any period of time, retaining

its original sensitiveness, the other varieties having lost theirs in proportion to the colour they have acquired. The iodide of cadmium, in addition to this valuable property of giving a stable collodion, is likewise extremely soluble, without being deliquescent, and being beautifully crystalline, is not liable to adulterations or impurities, and therefore well deserves to be generally tried.

"In order to preserve or, as it is stated, to improve the sensitiveness of collodion, some persons recommend the addition of a little ammonia. This, however, appears very unadvisable, since it necessitates the use of an acid bath; and although it may render the collodion less liable to change, it produces a contrary effect on the bath, since every plate immersed tends to neutralize a portion of acid, and at length rendering it neutral or even alkaline, brings about exactly the phenomena (fogging) described by Mr. Fenton.

"The cause of fogging (which is blackening of the whole negative on the addition of the developing solution) is owing to the bath becoming alkaline. This alkaline reaction is caused by oxide of silver in a state of solution in the bath.

"Oxide of silver is not soluble in water, nor in water containing nitrate of silver; but it is, in either case, abundantly dissolved if nitrate of ammonia be present, and the solution will be found to restore rapidly the colour of reddened litmus paper.

"The 'alkaline nitrate of silver bath,' therefore so called, is a solution containing, besides nitrate of silver, oxide of silver, dissolved in nitrate of ammonia.

"The nitrate of ammonia is produced by double decomposition when compounds of ammonium are used for 'iodizing' instead of those of potassium. Iodide of ammonium plus nitrate of silver equals iodide of silver plus nitrate of ammonia.

"The oxide of silver, which by its solution causes the alkalinity, is formed either by using collodion containing a little free ammonia in addition to the other ingredients, as sometimes recommended, or by attempting to neutralize an acid bath with potash or ammonia, and inadvertently adding an excess.

"So that if ammonia or salts of ammonia in any shape have been added to the collodion, or to the bath, it will be necessary from that time forward to examine more carefully than we otherwise should have done, that the faintly acid condition of the bath, so essential to the production of a good picture, is not destroyed.

"With ordinary collodion, however, even when quite colourless, the bath may always be used perfectly neutral, permitting the developing solution to be left on twice or three times as long as is necessary, without the slightest fogging, provided that the nitrate of silver is pure and the bath has not acquired fogging propensities by prolonged use. No pure alkaline iodide can ever render the bath alkaline; the only effect on immersing a plate covered with collodion is to remove a portion of silver and substitute an equivalent quantity of potassium, ammonium, &c., so that a portion of nitrate of silver is merely replaced by a portion of nitrate of potash or ammonia, which, being neutral, cannot in this respect affect the state of the bath. With the iodides of the metals, such as iron, zinc, cadmium, or arsenic, the bath, on the contrary, will soon become apparently acid from the presence of the nitrates of those metals which, as before stated, redden litmus.

"In all cases, excepting when free ammonia has been added to the collodion, the silver solution has a tendency to become acid rather than alkaline, both from the frequent presence of free iodine in the collodion, which sets free nitric acid in the bath, and also from the slow formation of acetic acid from the alcohol and ether washed out from the plates that have been immersed. The effect of free iodine in the

collodion is not, however, chemically the same as that of nitric acid in the bath; for nitrate of silver is, like all other nitrates, a nitrate of the oxide of silver. When, therefore, free iodine acts on the silver solution, it liberates oxygen as well as nitric acid, the result being that an iodate as well as an iodide of silver is formed; the effect of the former should therefore be ascertained, in order to clearly understand the action of brown collodion. When a great deal of iodine has been set free by long keeping, making the collodion very dark-coloured and insensitive, I found that the addition of a little oil of cloves, in the proportion of four drops to each ounce, causes a surprising increase of sensitiveness; and some time ago I always used such a mixture for the production of positives on glass, from a belief that a better colour and more perfect gradation of tints were obtained in this way than by any other method.

"At this time my pictures were constantly liable to solarization (or darkening of those parts that ought to be whitish), when using the ordinary collodion and developing by pyrogallic and nitric acids; but lately, while seeking for difficulties in order to discover their causes, this tendency to solarization quite disappeared, although using the simplest materials; neither was I able to produce it by taking objects in the most unfavourable conditions of light and shade, nor by any addition to the collodion. Accidentally trying the effect of a minute quantity of nitrite of silver in the nitrate bath, I obtained it again in perfection, and was able at once to understand how it occurred formerly, for at that time I always made use of nitrate of silver that had been strongly fused, and in which a portion of nitrite had thus been formed, while latterly only the crystallized salt had been employed. The effect of oil of cloves and iodine in the collodion was to counteract that of the nitrite; but when pure crystallized nitrate is used, no such additions are required.

"It is remarkable, that although oil of cloves greatly increases the sensitiveness when brown collodion is used, no such effect is produced by its addition to colourless collodion with an acid bath, proving that free iodine in the former is not exactly similar to nitric acid in the latter. To compensate for the bad effects of the nitrite on the colour of positives, it has the important property of much increasing the sensitiveness and rapidity of the surface, allowing pictures to be taken instantaneously with far less light than is usually required; and it is thus particularly suited to negatives, in which the colour by reflected light is of no importance, while it adds to the opacity of the dark parts of the picture. Its effect on the colour of positives is chiefly seen when pyrogallic acid is used for developing, and becomes more marked as the picture dries, when the tint of the reduced silver becomes darker, and of a greenish colour in the most exposed parts, while with pure nitrate, as the moisture evaporates, it becomes lighter, and the details appear more distinctly represented in various shades of one colour. As this nitrite is formed when the nitrate is overheated, it generally exists in 'lunar caustic' to a greater or less extent; but as this substance, from a want of crystalline form, is easily and frequently adulterated, it is much better to add the nitrite to a solution of the crystallized nitrate in quantities less than half a grain to an ounce of a thirty-five grain solution, for too large an amount causes a fogging of the clear parts of the picture. It is easily obtained by fusing pretty strongly a mixture of equal parts of nitre and nitrate of silver; the fused mass being dissolved in a small quantity of boiling water, and left to cool; the nitrite of silver then crystallizes in the shape of long, slender needles, which may be removed, and pressed in blotting-paper to dry them; by re-crystallizing they are obtained quite pure.

"The strength of the solution of nitrate of silver ought to be proportional to the

quantity of iodide in the collodion, at least so far that it cannot be diminished beyond a certain point (depending on the collodion used) without a great loss of sensitiveness, or, what is exactly similar, if we use a bath of a certain strength, the quantity of iodide cannot be increased to any amount, but must be limited by the proportion of nitrate of silver: with a thirty-five grain solution of the latter, four grains of iodide to the ounce of collodion answers very well; but if the quantity be increased to six grains, there is a great loss of sensitiveness and intensity, the effect being similar to that arising from an insufficient amount of alcohol in the collodion, in consequence of the iodide of silver being deposited superficially, or even falling off the surface into the silver bath. The mistake of over-iodizing the collodion is generally committed with the view to obtain greater opacity of the reduced silver, apparently from an idea that the iodide only is reduced, while in fact a large portion of the reduced silver is derived from the nitrate, so that a very little iodide in the film is sufficient to give intense negatives. For this purpose the collodion should be colourless, or nearly so, or at least, if coloured, it must not be owing to free iodine (which is ascertained by allowing a drop to evaporate on a piece of starch or a crumb of bread, and then moistening with water; a trace of iodine is detected by the black colour resulting); the bath should likewise be neutral, or nearly so, and the developing fluid should contain no more acetic or tartaric acid than is sufficient to prevent blackening of clear parts; after the pyrogallic solution has apparently done its utmost, the intensity may be further increased by pouring on a fresh portion, mixed with some of the silver solution, which immediately adds to the opacity of the negative, a fresh deposit taking place on the parts already reduced. By the use of the nitrate as before mentioned, still greater opacity may be obtained, together with the utmost rapidity; at the same time there is none of that violent contrast of light and shade which appears to result from the addition of iodide of iron, as an accelerating agent, to the collodion. I believe that salts of iron have not as yet been used for developing negatives, in consequence of the want of opacity in the reduced parts. I find, however, that the proto-acetate of iron obtained by mixture of solution of acetate of lead and sulphate of iron, is capable of producing intense negatives, resembling in all respects those obtained by pyrogallic acid, while it has the advantage in point of economy; but I have not as yet made a sufficient number of experiments to enable me to determine the strength of the solution best suited to the purpose; it need not be very great, somewhat less than eighteen grains to the ounce, for if it contain so much as this, it is liable to produce universal blackening when first prepared; but in a few days, when a portion of peracetate has formed, it answers very well. My object in endeavouring to find a substitute for pyrogallic among the iron compounds, is not to add to the number of developing fluids and the perplexity of a beginner. Where pyrogallic acid can be obtained pure, and is found to answer perfectly, in that case it is preferable to anything else; but as this may not always be, it is useful sometimes to know of a substitute that can be prepared wherever green vitriol and sugar of lead can be found, for these substances, even when impure, are very easily purified by re-crystallizing from a solution in boiling water; which is not the case with pyrogallic acid, to which noxious ingredients might easily be added, accidentally or intentionally, from which it would puzzle a chemist to free it.

"By knowing the quantity of iodide contained in a collodion, it is easy to ascertain the amount of silver that the bath loses for each ounce, and thus to know exactly how much nitrate should be added to maintain the same strength; thus, with a collodion

containing four grains of iodide of ammonium to the ounce, each ounce expended removes four seven-tenths grains of nitrate of silver, but with four grains of iodide of potassium the quantity of nitrate consumed is only four one-tenth grains. In the first case nitrate of ammonia, in the second nitrate of potash, accumulates in similar proportions, but the ammonia salt has the advantage of being easily dissipated on evaporating the bath and gently fusing, leaving only salts of silver behind, while the nitrate of potash is quite fixed."

Mr. Hardwich's Researches.—Having thus quoted Mr. Ash Hadow's paper, I shall proceed to make the reader acquainted with the results of some most valuable researches as to the nature, properties, and capabilities of this most useful photographic medium, conducted by Mr. F. Hardwich, of King's College, London. I may add, that both these gentlemen well deserve the thanks of every photographer, for the care with which they have studied this important branch of the art, and the generous manner in which they have given the results of their researches to the public. Mr. Hardwich's remarks I quote from the Photographic Journal. This gentleman was led to consider the condition of the film most favourable for the production of pictures to be viewed by reflected light, by a paper translated from the French of M. Gaudin, and published in the Journal of the Photographic Society.

"My attention," he says, "was first directed to the positive process, quite, as I may say, accidentally; and when I was comparatively ignorant of the effects which would be produced by varying the proportions of the ingredients in the sensitive collodion; having adopted Archer's method of iodizing, viz., by adding a certain quantity of a saturated alcoholic solution of double iodides of potassium and silver, I failed, from the alcohol I employed being in too concentrated a state. I had previously rectified it from carbonate of potash, and its solvent power being thus diminished, the amount of iodides taken up was not sufficient for the purpose. When I say 'I failed,' I mean it in the sense that I was not able to obtain good negative pictures, which was the object I had then in view. They were all sadly wanting in 'intensity,' and I found it impossible to 'print' from them with anything like success. However, I soon observed that these unsatisfactory negative pictures looked exceedingly well when viewed as positives by reflected light; there was a nice gradation of tone about them which pleased me, and I adopted the plan of backing them up with black varnish, and preserving them in that form.

"Now at this time, as I said before, I was not aware that I was employing a collodion with an unusually small proportion of iodide; but if I had been, I should not have referred my success in producing positives to that cause. I had never seen it stated in any work with which I was acquainted, that a difference ought to be made in the two cases. The directions I had received were these:—'If you wish to obtain a positive, expose in the camera for half the usual time, and develop with sulphate of iron, to get a bright deposit of metallic silver.' Now the object I have in view is to prove that, if we wish to obtain the best results, we must use not only a different developing fluid, but also a different collodion and a different nitrate bath, in the case of negative and positive pictures respectively. It may be asked, 'What is the inferiority of which you complain in the positives produced by collodion, as it is ordinarily sold?' I answer, it is this: 'That the whole of the picture is not to be seen at once upon the surface of the glass.' Suppose you are taking a portrait, which I think will readily be allowed to be one of the most severe tests of a collodion that can easily be applied, it will be found that the high lights, such as the forehead, the hands, and

especially the shirt of the sitter, come out with exceeding rapidity, and in a degree out of all proportion to the time taken by the shadows and half-tints to impress themselves; the consequence of this is, that, stop the action of the light when you will, you do not obtain a perfect picture. After backing up with the black varnish, it will be seen either that the high lights are good, and the rest of the figure almost invisible, or, on the other hand, that the coat, dress, &c., are very clear, whilst the face and hands present an unvaried white and flat surface, without any detail or distinction of parts. These peculiarities do not depend upon the time of exposure, nor in any way on the developing fluid, but simply on the fact that the collodion employed is not capable of giving such a film of iodide of silver as is adapted to produce impressions visible by reflected light.

"Having thus stated the principal difficulties which we have, ordinarily speaking, to encounter, I proceed to show how they may be overcome, and what is the best sensitive mixture for that purpose. In making my experiments, I first prepared simple collodion by dissolving soluble cotton, four grains, in five drachms of ether and three of highly-rectified alcohol. These are the proportions recommended by Mr. Hadow, and I believe them to be the best that can be used. They do not, of course, apply to commercial ether, which already contains a considerable quantity of alcohol. In order to iodize my collodion, I employed iodide of ammonium (purified with care) in four different proportions, viz., four grains to the ounce, two grains, one and a-half grain, and one grain.

"The films produced by these four mixtures, after dipping the plate in the nitrate bath, were very different in appearance; the lowest of all was pale, of a bluish opalescent tint, so transparent that the letters of a newspaper could be read through it with facility; the second somewhat similar; the third of a grayish hue, but still comparatively transparent; the highest of all, viz., the four-grain, creamy and opaque.

"The photographic properties of the films differed considerably; after comparing numerous results, I was satisfied that the two-grain solution was superior to the four-grain for the purpose I intended it; more of the details of the picture were visible at once on the surface of the glass, and there was less tendency to the over-done, flat appearance before complained of. Between the 'two-grain' collodion, the 'grain and a-half,' and 'the grain,' there was likewise a difference, but not to the same extent; on the whole I was disposed to give the preference to the 'grain and a-half,' the last of all requiring too long an immersion in the bath to be used with advantage.

"It was not my intention, at the time I began these experiments, to make any variation in the amount of soluble cotton generally used; I found that four grains to the ounce gave a strong and even film upon the glass, and such being the case, there appeared nothing more to be desired; however, a fact that came under my notice soon afterwards, altered my determination; I began to suspect that the weak solutions of nitrate of silver I was employing did not penetrate the film properly, and consequently I wished, if possible, to remove this objection by diminishing its thickness. The result of the change proved even better than I had anticipated, although the solutions were rather more troublesome to manipulate with; I obtained invariably more perfect pictures; the gradation of tints was now decidedly superior to anything that I had met with before, and although I could not immediately explain the reason, I was satisfied that I had gained an advantage.

"The composition of the collodion which I found after many trials to work the best, is as follows:—Ether, five drachms; alcohol, three drachms; soluble cotton, one

and a-half grain; iodide of ammonium, one and a-half grain—instead of this, two grains of each may be used, or even as little as one grain, without very materially affecting the result; but in the latter case the mixture is so fluid, that it is apt to run down the neck of the bottle while attempting to pour it on to the plate. These proportions become very simple when it is considered that they are at once produced by diluting down an ordinary negative collodion rather more than one half, with the proper mixture of alcohol and ether.

"There is one point which I ought to mention: by diminishing the proportion of iodide in the film, and by diminishing the soluble cotton, the sensitiveness is increased. Why is it that these weak films give better half-tones than the opaque ones? Because they are more sensitive to feeble rays of light! I made many experiments to determine this, and I have no hesitation in stating that such is the fact. Neither is it difficult to conceive why it should be so, because, as it has been remarked, the more dilute the solutions from which iodide or chloride of silver is precipitated the more gradual the precipitation, and the more finely divided will the particles of the precipitate be; we can well understand that, such being the case, they ought to be more sensitive to light; we must not, however, confound 'sensitiveness' with 'intensity.' I would use this latter term to signify that the deposit of metallic silver producing the image is thick, and obstructs the luminous rays of light strongly, so as to show well as a negative; 'intensity,' I imagine, relates in some degree to the number of the particles of iodide of silver—in other words, to the thickness of the film; but 'sensitiveness' is independent of this. Now, 'intensity' is required for negative pictures, but it is not required for positives, and therefore, in such a case, I would have as little iodide as possible.

"At the risk of repetition, I will give a short recapitulation of the conclusions which I wish to establish. They are these:—That no proportion of alkaline iodide in collodion beyond that which gives the transparent opalescent film, is adapted to produce a perfect image, visible in every part by reflected light. Allowing that a photographic picture is produced by chemical rays of light acting in various degrees on the several parts of a sensitive surface, it becomes necessary that the particles of iodide composing that surface should be in a peculiar state both as to number and as to fineness of division, in order that the more intense and the feebler rays should work uniformly together, the tendency being in the former, so to speak, to get a-head and outrun the latter; while a diminution in the proportion of iodide assists the action of the feeble rays by producing a more finely-divided deposit, and curbs the violence of the more energetic rays by lessening the number of the particles.

"I shall now proceed," Mr. Hardwich continues, in a subsequent paper, "to consider the proper strength of the nitrate bath and of the developing fluid.

"With regard to the nitrate bath, there were two points of interest to be ascertained,—1st, whether the salt of silver could be used in an accurately neutral condition, and, if so, what are the best proportions; 2nd, the effects of adding nitric acid in graduated quantities.

"Three solutions of nitrate of silver were prepared, of different strengths; A, forty grains to one ounce of distilled water; B, thirty grains; C, twenty grains: all were carefully neutralized, and saturated with iodide of silver.

"On immersing a plate coated with a four-grain iodide collodion in each of these, it was found that with bath C the decomposition of the alkaline salt was imperfect. However, with the proportion of iodide reduced from four grains to two grains, or

one and a-half grain, the appearance of the film was the same in each bath, showing that even the lowest proportion of nitrate of silver was sufficient for the conversion of the whole of the iodide of ammonium into iodide of silver.

"A comparison was next made of its photographic properties, the one and a-half grain collodion being used in every case.

"1st. *Sensitiveness.*—Here the difference was not very marked, perhaps the twenty-grain solution had a little the advantage; at all events it was plain that nothing had been lost in this respect by diminishing the proportion of nitrate.

"2nd. *Clearness of Image.*—In every case the image was perfectly clear, in the sense that there was no 'fogging' or reduction of metallic silver on the transparent parts, but there was a difference in the appearance of the 'lights;' when baths A and B were employed, they were always slightly obscured, especially the shirt and forehead of the sitter, by a yellowish deposit of silver, which seemed as if it had been precipitated after the proper development was complete. I conclude that this deposit was derived from the free nitrate of silver on the surface of the film, which being in a more concentrated state in the two former cases, was the more readily acted upon by the developing fluid; however, it may not be that the effect here alluded to will invariably follow when a neutral bath so strong as forty grains to the ounce is used; much depends, no doubt, upon the nature of the developing agent; indeed the two must be associated together, the strength of one varying inversely with that of the other.

"The conclusions arrived at are these, that with the dilute iodized collodion, nitrate of silver in the proportion of twenty grains to the ounce, gives equal sensibility and in every respect the same perfection of image as when used of greater strength; besides this, it has the merit of economy and superior cleanliness of manipulation; if the proper precautions are observed, such a bath will remain constant in its action for a length of time.

"Before proceeding to the developing fluid, there yet remains to be considered, as originally proposed, the effect of adding nitric acid in graduated quantities to the neutral nitrate bath; my experiments in this direction are, I am sorry to say, as yet incomplete; however, two or three facts of importance are manifest, viz., that it is impossible to lay down any general rule as to what the effect of adding the acid will be, unless we take into account all the other circumstances of the case; no doubt there will invariably be a loss of sensitiveness, but whether or not advantages will be gained in other respects, seems to depend upon further considerations. When collodion positives are taken by solutions modified as I have proposed, it will be found that the smallest amount of free acid, even such as cannot at once be detected by test-paper, will sadly injure the 'half-tones' of the picture.

"On the other hand, many photographers advocate the use of nitric acid, and state that they obtain a better result by means of it.

"In explanation of this seeming discrepancy I would suggest (and the views I entertain are borne out by my experiments as far as they have gone), that the amount of free nitric acid which may be added to the bath with impunity depends mainly upon the strength of the solution of nitrate of silver; strength of bath is favourable to reduction, nitric acid is opposed to it, consequently the two, to a certain extent, balance each other. But besides this, I am inclined to think that something depends upon the thickness of the film of iodide of silver; perhaps it may be that the particles of iodide being less in number, are more easily attacked; but, at all

events, it seems necessary to regulate the acid, both in the bath and the developing fluid, with greater care when weak films are employed than under contrary conditions.

"It is important then, and indeed essential, that the dilute nitrate bath should be preserved accurately neutral; this may easily be effected by adding a little carbonate of soda and so setting free carbonate of silver, which can be allowed to remain continually at the bottom of the bottle in which the bath is kept; if, however, iodide of ammonium is used in the collodion, this plan does not succeed, because nitrate of ammonia, which will then be formed in the bath, has the property of dissolving carbonate of silver and forming with it an alkaline solution; in that case it is better to keep a piece of blue litmus-paper always in the solution of nitrate, and when the colour is perceived to be changed by the small amount of acid liberated by the free iodine in the collodion, to add ammonia graduated to fortieths of a minim until the evil is removed.

"Having now finished what I have to say on the subject of the nitrate bath, it only remains that I should speak of the development of collodion positives, in order to complete my paper. The deposits which constitute the light portion of these pictures consist, in all cases, excepting where the bichloride of mercury is used, of metallic silver; but it may be useful to class them under two heads, according as they do or do not possess metallic lustre.

"The first is a surface bright and sparkling like frosted silver, very white when produced in perfection, but with occasionally a greyish or tinfoil hue.

"The second is dull and without lustre, of a whitish tint slightly inclining to yellow or grey; there is no appearance of a metal about it, the colour being more like that of a piece of chalk.

"These two varieties require exactly opposite conditions of developing fluid to produce them. From what I can gather from my own experiments, and from the observation of others, it would seem that the first is obtained by means of a reducing agent, checked, as it were, in its action by the presence of a strong acid, consequently the development proceeds slowly and gradually, and the particles of silver are large and crystalline; on the other hand, the second variety results when the action of the developer is sudden and violent, no impediment being offered by the presence of acid except in minute quantity. The particles of metallic silver are here smaller than before, and being comparatively amorphous, they reflect light in a different manner. The distinction in the two cases, if these views are correct, lies in the amount and strength of the acid used; in the one it is simply sufficient to whiten the picture slightly by preventing the precipitation of oxide; in the other, being increased in quantity, it tends to retard the development as well. In conducting these experiments the action of several different developing agents was compared, viz., pyrogallic acid, the same with subsequent whitening by bichloride of mercury, protonitrate of iron, and protosulphate of iron.

"1st. *Pyrogallic Acid.*—This gives, under certain circumstances, a beautifully white deposit of silver, free from lustre; it should be used in the proportion of three grains to the ounce, with a small quantity of nitric acid; if too much of this substance be added, the deposit is more metallic, but the half-tones are not properly brought out, so that pyrogallic acid is not adapted to produce what I have termed the first variety; so also it does not succeed when the proportion of nitrate of silver in the bath is reduced to twenty grains to the ounce; in that case the development

becomes imperfect in parts of the plate, and large patches of a blue or greenish colour are seen.

"2nd. *Pyrogallic and Acetic Acid, with subsequent Whitening by Bichloride of Mercury.*—I was unsuccessful in my attempts to produce good pictures by this plan; the colour of the image was not sufficiently white, but had invariably a bluish tint, which was particularly unpleasant; other photographers, I am aware, have produced excellent results with bichloride of mercury, and it may be that the extreme tenuity of the film I employed was one cause of the blueness and transparency. Another objection appeared to be that the details of the picture were slightly injured by the action of the bichloride, and the whole image reduced to a certain extent in intensity; this was more apparent after blackening by means of ammonia, and then again whitening a second time.

"3rd. *Protonitrate of Iron.*—This substance is peculiar in producing an image of brilliant metallic lustre, without the addition of any free acid, hence it may at first sight seem to be an exception to the observations that have just been made on this subject; it is remarkable, however, that protonitrate of iron should be so feeble a reducing agent when compared with the corresponding sulphate; probably the reason may be, that in passing into the state of persalt, a portion of the oxygen required is furnished by the decomposition of the nitric acid itself, and hence less would be abstracted from other sources. In experimenting with proto-nitrate of iron, I found a difficulty sometimes in bringing out the half-tones of the picture properly. To obviate this, it is advisable to use the solution of the salt in as concentrated a state as it can be procured, and to increase the proportion of nitrate of silver in the bath, if required, from thirty-five grains to forty grains to the ounce.

"With the dilute nitrate bath of twenty grains to the ounce, protonitrate of iron failed entirely to develop the image, thus affording most conclusive proof of the close relation which the strength of the bath bears to the energy of the development.

"4th. *Protosulphate of Iron.*—This salt appears better adapted for the purpose than either of the others when the twenty-grain bath is employed. In order to obtain the tint which has been characterized as a dead white with absence of metallic lustre, it must be used of such a strength that the picture comes out almost instantaneously in all its details; it occurred to me at first that the gradation of tone would be injured somewhat by this violent method of proceeding, but I did not find on trial that such was the case; neither is there any indication of fogging or over-development if the solution be poured off from the plate tolerably quickly.

"The proportions I have been in the habit of using are these:—Protosulphate of iron pure, fifteen to eighteen or twenty grains; acetic acid (glacial) minims viij.; distilled water one ounce.

"In the place of the acetic acid, strong sulphuric acid minim half, or nitric acid minim a quarter, with fifteen drops of alcohol may be used; the alcohol certainly has the effect, as has been stated, of causing the solution to flow more evenly; but it appeared to me, that if present in too large quantity, the liability to 'specks' and 'dirty marks' was increased.

"If the solution of protosulphate is in too concentrated a state, it will be difficult to pour it on the plate sufficiently quickly to cover the whole surface before the action begins; in such a case, after fixing with the cyanide, curved lines will be seen, such as would be produced by a wave of fluid flowing forwards and resting for an instant at a particular spot.

"On the other hand, if the solution is too dilute, the image becomes slightly grey and metallic on drying.

"For fixing the picture by removal of the unaltered iodide of silver, cyanide of potassium appears preferable to the hyposulphite of soda; it may be used of such a strength as will clear the plate gradually in about half a minute or so, and is easily washed away by pouring a stream over the plate for a short time.

"For 'backing up' I employ two varnishes, both of which dry speedily; the solvent is different in the two cases, and that of the black japan does not appear to act upon the transparent layer beneath. A complaint is sometimes made that collodion positives do not show to advantage through the glass, but I have not myself been able to distinguish at all between the two sides, excepting in cases where the picture was slightly over-exposed.

"With regard to the time required for taking a portrait on a tolerably bright day, as giving some indication of what the degree of sensitiveness of the plates might be, I would say that with a Ross's portrait lens of two and a quarter inches, having a diaphragm of an inch and three quarters aperture, an exposure in the camera of two to three seconds is the average; when distant objects are taken with the full aperture of the lens, it is hardly possible to remove and replace the cap with sufficient quickness."

Mr. Horne's Process.—Mr. Horne has been one of the earliest and most successful operators, and has published an account of the particular manipulations required in the collodion process. By his permission, I am enabled to give the process he adopts in his own words. As regards the choice and preparation of the plate itself, the operator cannot do better than follow the directions of Mr. Hardwich, which I have already recorded. The plate selected, having a clean and perfectly dry surface, and taking care to handle it as little as possible, the next operation is that of

Fig. 64.

"*Coating the Plate.*—Taking it from the clean dry leather in which it has been wrapped, there are several ways by which the iodized collodion may be applied, some preferring a piece of India-rubber fastened to the back as a handle, others supporting it on the ends of the fingers of the left hand (Fig. 64); while others, again, content themselves by sacrificing a small portion of one corner, or by the use of an instrument called the pneumatic plate-holder, which appears to answer well. But whichever plan is adopted, the plate must be held by the left hand perfectly horizontal, and then with the right a sufficient quantity of collodio-iodide should be poured into the centre, so as to diffuse itself equally over the surface. This should be done coolly and steadily, allowing it to flow to each corner in succession, taking care that the edges are all well covered. Then gently tilt the plate, that the superfluous fluid may return to the bottle from the opposite corner from which the plate is held. At this moment the plate should be again brought into a vertical position, when the diagonal lines caused by the fluid running to the corner will fall one into the other, and give a clear flat surface. To do this neatly and effectually, some little practice is necessary, as in most things; but the operator should by no means hurry the operation, but do it systematically and quietly, at the same time not being longer over the operation than is actually necessary, for collodion, being an ethereal com-

pound, evaporates very rapidly. Many operators waste their collodion by performing this operation in great haste; but haste is not necessary, for an even coating can seldom be obtained if the fluid is poured on and off too rapidly; it is better to do it steadily, and submit to a small loss from evaporation, and at any future time, if the collodion becomes too thick, to thin it with the addition of a little fresh and good ether.

"*Exciting the Plate.*—Previous to this it is necessary to have the bath ready, which is made as follows:—

Nitrate of silver	10 drachms.
Distilled water	20 ounces.
Iodide of silver	5 grains.

Dissolve and filter.

"The object of putting the iodide of silver is that the nitrate may be saturated with it, or the plates would otherwise be robbed of a certain portion. Now to saturate the nitrate properly, it is necessary the iodide should be freshly precipitated, therefore the best plan is to proceed as follows:—

"Dissolve the ten drachms of nitrate of silver in two ounces of distilled water, and add to this five grains of iodide of potassium previously dissolved in about two drachms of distilled water. Upon mixing these, the iodide is thrown down, and redissolved by the concentrated solution of silver, when the remainder of the water, namely, eighteen ounces, may be added, and the solution very carefully filtered.

"The quantity of this fluid necessary to be made must depend upon the form of trough to be used, whether horizontal or vertical, and also upon the size of plate. The trough used by the writer is the vertical, though many still prefer the former, and attach, as before described, a piece of India-rubber to the back of the plate as a handle whilst applying the collodion, and to keep the fingers from the solution whilst dipping in the bath. With the vertical troughs a glass dipper is provided upon which the plate rests, preventing the necessity of any handle or the fingers going into the liquid. Having then obtained one or other of these two, and filtered the liquid, previously free from any particles of dust, &c., the plate is to be immersed in it steadily and without hesitation, for if a pause should be made at any part, a line is sure to be formed, which will print in a subsequent part of the process.

"The plate, being immersed, must be kept there a sufficient time for the liquid to act freely upon the surface, particularly if a negative picture is to be obtained. As a general rule it will take from two to four minutes, varying with temperature and make of the collodion. In very cold weather, or indeed anything below 50° Fah., the bath should be placed in a warm situation, or a proper decomposition is not obtained under a very long time. Above 60° the plate will be almost certain to have obtained its maximum of sensibility by two minutes' immersion, but as the plate cannot injure by remaining a longer time in the bath, it is better in all cases, when a negative picture is required, to give time for the whole of the iodide in the collodion to be thoroughly acted on by the nitrate of the bath.

"To facilitate the action, let the temperature be what it may, the plate must be lifted out of the liquid two or three times, which also assists in getting rid of the ether from its surface. If this is not thoroughly done, a uniform coating cannot be obtained; but on no account should it be removed until the plate has been immersed about half a minute, or marks are apt to be produced.

"Having obtained the desired coating, the plate is then extremely sensitive to white light, and every precaution should be taken to exclude ordinary daylight. The best way to do this is to hang over the window two or three thicknesses of yellow calico, by which means the light which passes through will be amply sufficient for manipulation, and at the same time produce no injury to the sensitive plate. If this cannot be done, the room must be closed against any portion of daylight, and a candle alone employed, placed however, at a distance from the operator, to give the requisite light.

"The plate thus rendered sensitive must then be lifted from the solution and held over the trough, that as much liquid as possible may drain off previous to being placed in the frame of the camera, otherwise the action will not be equal over the whole surface. It must not be allowed to dry, however; but, in order to obtain its full maximum of sensibility, it should be damp without superfluous moisture. It is thus imperative that the exposure takes place within a few minutes after removing the plate from the bath. This renders collodion of very little value for taking views, as in such situations we cannot command the use of a dark-room.

"The question is often asked—How soon after the coating the plate with collodio-iodide, should it be immersed in the nitrate bath? We have said the time of immersion is dependent upon temperature and make of collodion, so likewise must we be governed as to time before immersion. To make collodio-iodide or xylo-iodide—for, chemically speaking, there is no difference in the two—it is necessary that the ether should contain a certain quantity of alcohol, or the different articles are not soluble; therefore, if we take a fresh bottle and coat the plate from this while it contains its full dose of ether, and with the thermometer ranging between 60° and 70°, the evaporation of this article will be very rapid, and consequently a tough film soon formed; but if, on the other hand, we are using an article which has been in use some time, and many plates, perhaps, coated, the proportion of alcohol will be much greater, and not being of so volatile a nature, will necessarily take a longer time to acquire the necessary firmness for immersion. Hence it is evident we must be guided by circumstances. If, for instance, after coating a plate, we find on immersion it does not colour freely, we have then reason to suppose the plate has not been immersed sufficiently quick; but if, on the other hand, we find the film very tender, and it cracks upon drying, then we have reason to know that plates prepared from that bottle must not be immersed quite so soon. The larger the proportion of alcohol the more tender the film, but the more sensitive will be the plate, and the quicker and more even will be the action of the bath.

"The next question also often asked is—How long must be the exposure in the camera? a question more difficult to answer than the last, and which practice alone can determine, combined with close observation of those parts which should be the shadows of a picture. If, for instance, in developing, we find those parts less exposed to the light than others develop immediately the solution is applied, then we have every reason to suppose the exposure has been too long; but if, on the contrary, they develop very slowly, we have proof that the time allowed has not been sufficient to produce the necessary amount of action. In a good picture we should see first the whites of the dress appear, then the forehead, after which we shall find, if the light has been pretty equally diffused, the whole of the face and then the dress.

"Much will, of course, depend upon the arrangement of light, for if the sitter is not placed in a good aspect, by which is meant a good diffused light, the prominent

parts only will come out; in other words, to produce the necessary amount of action to obtain the others, the high lights are so overdone that the picture prints raw and cold.

"Can I produce portraits at my drawing-room window? This is another common question, and the reply must necessarily be, Yes, if you have sufficient light, and can so place your camera that the sitter may be pretty equally illuminated, and not one half receiving nearly all the light; if it does, one side may be amply developed and the other scarcely visible.

"In cases of this description the necessary effect may often be produced by placing a white screen so as to reflect a portion of light upon the darkened side; but, upon the whole, a light of this character is better adapted for producing positive than negative pictures upon glass.

"*The Development of the Image.*—To effect this it must be taken again into the room where prepared, and with care removed from the slide to the levelling stand. It will be well also to caution the operator respecting the removal of plate. Glass, as before observed, is a bad conductor of heat; therefore if, in taking it out, we allow it to rest too long on the fingers at any one spot, that portion will be warmed through to the face, and as this is not done until the developing solution is ready to go over, the action will be more energetic at those parts than at others, and consequently destroy the evenness of the picture. We should, therefore, handle the plate with care, more as if it already possessed too much heat to be comfortable to the fingers, and we must therefore get it on the levelling stand as soon as possible.

"Having then got it there, we must next cover the face with the developing solution. This should be made as follows:—

Pyrogallic acid	10 grains.
Distilled water	5 ounces.
Glacial acetic acid . . .	1 drachm.
Spirits of wine	½ a drachm.

Mix and thoroughly filter.

"Now, in developing a plate, the quantity of liquid taken must be in proportion to its size. A plate measuring five inches by four will require half an ounce, less may be used, but it is at the risk of stains; therefore we would recommend, that half an ounce of the above be measured out into a perfectly clean measure, and to this from eight to twelve drops of a fifty-grain solution of nitrate of silver added.

"Pour this over the surface, taking care not to hold the measure too high, and not to pour all at one spot, but having taken the measure properly in the fingers, begin at one end, and carry the hand forward; immediately blowing gently upon the face of the plate, which has the effect, not only of diffusing it over the surface, but causing the solution to combine more equally with the damp surface of the plate; it also has the effect of keeping any deposit that may form in motion, which if allowed to settle, causes the picture to come out mottled. A piece of white paper may now be held under the plate, to observe the development of the picture; if the light of the room is adapted for viewing it in this manner, well; if not, a light must be held below; but, in either case, arrangements should be made to view the plate easily whilst under this operation, a successful result depending so much upon obtaining sufficient development without carrying it too far.

"In some instances it is better not to mix the nitrate of silver solution with the pyrogallic until after the latter has been poured over the plate, but in no case must it be mixed on the plate, the solution must be poured off into the measure and the nitrate

added. In this way we can judge better of the intensity of the picture, for when the solution is off, the plate can be held up to the light and the image viewed through. Care should be taken that the nitrate of silver solution is free from deposit.

"The author has also found a weak developing solution, as given above, far more successful in obtaining gradation of tone than when stronger, for, in the latter case, the action will be very energetic on those parts reflecting the most light, and, consequently, become overdone before other portions, such as dress, &c., have become sufficiently visible. The addition of an extra portion of nitrate of silver will be found to improve the tone, but this may be effected also without adding it to the pyrogallic solution; and, in many instances, it will be found a better plan to re-dip the plate in the bath, after exposure in the camera, particularly if any considerable time has elapsed between the excitement of the plate and development of the picture, for the plate having dried unequally does not allow the same uniform development as when well moistened over the surface.

"As soon as the necessary development has been obtained, the liquid must be poured off, and the surface washed with a little water, which is easily done by holding the plate over a dish and pouring water upon it, taking care, both in this and a subsequent part of the process, to hold the plate horizontally, and not vertically, so as to prevent the coating being torn by the force and weight of the water.

"*Fixing the Image.*—Which is simply the removal of iodide from the surface of a plate, is effected by pouring over it, after the water, a solution of hyposulphite of soda, made of the strength of eight ounces to a pint of water. At this point daylight may be admitted into the room; and, indeed, we cannot judge well of its removal without it. We then see the iodide gradually dissolve away, and the different parts left more or less transparent, according to the action of light upon them.

"It then only remains to thoroughly wash away every trace of hyposulphite, for, should any of this salt be left, it gradually destroys the picture. The plate should, therefore, either be immersed with great care in a vessel of clean water, or, what is better, water poured gently and carefully over the surface. After this it must be put in a proper place to dry, or held before a fire.

"It may be as well to state, any clean filtered water will answer for washing, distilled being only required for the solutions of nitrate of silver, &c.

"Having, by the foregoing means, obtained and fixed a negative photographic image on glass, and which is capable of producing positives upon paper by the ordinary photogenic printing; it is as well, previous to obtaining these, to render the tender film of collodion less liable to injury. This is best accomplished by—

"*Varnishing the Plate.*—There are two kinds of varnishes which may be used for this purpose—the spirit and turpentine; of the latter kind the gum-dammer answers best, and indeed the only objection to its use is, that it requires forty-eight hours to dry—whereas with the former, which consists of spirit and a great variety of gums, the plate may be printed from within a few minutes. Some amount of care is necessary in the use of the latter, for if it is poured on the plate cold, the gums chill, and the picture is rendered opaque; therefore the best plan of proceeding is as follows:—

"Hold the back of the plate to a fire until warm through, care being taken not to make it too hot, or the varnish will not run properly; then pour the varnish on in the same manner as the collodion, returning the superfluous liquid to the bottle. Hold the plate again to the fire to drain off the spirit, when a beautiful surface will be obtained, making it difficult, at first sight, to judge which side has been varnished.

"The dammer varnish may be applied cold, care being taken to make it very thin, either with turpentine or camphine, otherwise it will be days before it is sufficiently dry to print from.

"There is also another kind of varnish which has been recommended by Dr. Diamond, viz., gum-amber dissolved in chloroform. This is used by many photographers, as it can be put on cold, and yet it dries directly upon evaporation of the chloroform, otherwise it possesses no advantage over the spirit, and is necessarily much more expensive.

Positive Pictures upon Glass.—Hitherto we have described the method of producing negative pictures only, but by slightly varying the process in developing the collodion pictures, most beautiful positives, equal to Daguerreotypes, may be obtained, and without their metallic reflection. These pictures are strictly, positive, for, when held to the light, they scarcely show as a negative. To produce them, a much shorter time is necessary for a sitting than for the production of a printing negative. They also require a modification in the development, that as bright a surface may be obtained as possible.

"It was shown by the author, in the early days of collodion, that this result might be obtained, to a certain extent, by mixing with the pyrogallic solution a very small quantity of nitric acid; but it has since been proved by Mr. Fry and others, that a better result may be obtained by the use of proto-sulphate and proto-nitrate of iron.

"The former salt is readily obtained, and in a very pure form. It should be used as follows:—Proto-sulphate of iron, ten grains; distilled water, one ounce; nitric acid, two drops. To develop the image, pour the above over the plate, taking care not to carry the development too far.

"The proto-nitrate may be obtained either by double decomposition, as recommended by Dr. Diamond, or by dissolving sulphuret of iron in dilute nitric acid, as recommended Mr. Ellis. The latter, being the most economical, we will describe first.

"To one ounce of nitric acid, and seven of water, add a small quantity of sulphuret of iron broken into fragments. Stand the vessel aside, that the sulphuretted hydrogen may escape, and the acid become saturated with iron. Pour off the liquid, and filter. Boil it again in a Florence flask to get rid of the sulphur, and again filter, when a dark green liquid will be obtained, which is the proto-nitrate of iron. This should be kept in well-stoppered bottles, and from air as much as possible, to prevent its changing into a per-nitrate, in which stage it is quite useless as a photographic agent.

"To develop the picture, mix one part of the above proto-nitrate with three of water, and apply it to the plate in the ordinary way, when a most beautiful clear image will be obtained.

"Dr. Diamond's method we take from the Art Journal. 600 grains of proto-sulphate of iron are dissolved in one ounce of water, and the same quantity of nitrate of baryta in six ounces of water; these being mixed together, proto-nitrate of iron and sulphate of baryta are formed by double decomposition; the proto-nitrate of iron being in solution, and the sulphate of baryta precipitated, the latter being easily removed by filtering the solution.

"The negative image being developed, a mixture of pyrogallic and hyposulphate of soda, which has undergone partial decomposition, is poured over the plate, which is gently warmed. Upon this the darkened parts are rendered brilliantly white by the formation of metallic silver. This picture being backed up with black velvet, assumes the air of a fine Daguerreotype, without any of the disadvantages arising from the reflection

of light from the polished silver surface. We have also seen a similar effect produced by Mr. Fry and Mr. Berger, by the use of the proto-sulphate of iron solution and pyrogallic acid. The image is first developed by the iron solution, which is then poured off, and another solution of pyrogallic is poured on, until the effect is produced. The pictures are fixed with the hyposulphite in the usual method."

The Author's Process.—I have now to offer some remarks on the collodion process as practised by myself, and I commence by reiterating my caution in favour of care and cleanliness, which is the motto it is impossible to impress too strongly on the mind of the reader. Before commencing operations, have everything as nearly as possible, in the following state:—The glass house must be scrupulously clean, and free from slops and dust; care must be taken that no ray of white light gains admittance through any chink or hole—the door will be the part most subject to this; the light used should be obtained through a piece of orange or red glass—a foot square will be quite large enough—and it should not face the sun. It may be necessary in very bright weather to have a curtain of yellow calico on a roller, so that it may be used or not, as may be required. There should be a deep tray to receive the washings, and this should have a waste-pipe, if possible, to prevent the accumulation of slops; the tray and water-tap should be as nearly as possible under the light, and if the water has to fall from any height, so as to fall with force, it will be necessary to tie a piece of old linen on the opening of the tap—by this means you will obtain a plentiful supply of water, which will fall so gently as scarcely to be felt by the finger; by this precaution you will not run any danger of washing off the collodion film. It will also be a great advantage to have the tap fastened to the supply-pipe by a couple of feet of vulcanized India-rubber, or flexible gutta-percha tubing, so that the plate especially a large one) may be supported on the tops of the thumb and fingers of one hand, while the other can swill the water over the surface with ease in every direction.

Have your exciting bath so placed that the yellow light may *rake* the surface of the plate when you lift it out to examine the state of the iodized and excited collodion film, but this should never be done until the plate has been at least a minute in the bath. You must also take care that the bath is sufficiently far away from the washing tap to prevent the risk of splashings from the latter when washing the plate. The developing glass should have a small stand for itself, covered with a sheet of blotting-paper folded half a dozen times, to be renewed when it becomes wet through. The collodion bottle should stand on another shelf, and the vessel holding the solution of hyposulphite of soda or cyanide of potassium should occupy another shelf—this must never be used for any other purpose, neither should the hypo-vessel ever be placed any where else—this latter shelf should be much lower than the others. You should have a towel for the hands, another for wiping out the slide after each plate—but "*papier Joseph*" is better—and a cloth for wiping up all slops. The developing-room I consider most convenient would resemble the following sketch (Fig. 65), supposed to be made when looking down from the roof—the shelving being about the height of a common table or a little higher:—

A, the window of orange glass; B, the shelf for the developing-bottle and vessel; C, the water-tap; D, the waste-pipe; E, the washing-tray; F, the main shelf or bench; G, the exciting bath; H, the shelf for collodion bottles; I, shelf on which may stand the dark slide when not in use; J, the shelf for the hyposulphite vessel; K, the body of the room; L, a curtain running on a rod with rings, to be drawn across

after the door is shut; M, the door; N and O, hooks for towels. The above will be found to be a most convenient dark-room; and it may be as well to say here, in reference to such places in general, never allow bottles, or any other articles *not in use*, to remain on the shelves or in the dark-room; have everything in its proper place, and have everything put away, and the dark-room cleared and *swept* out after the work is done for the day, so that it may be clean and *free from dust* for the next day's operations.

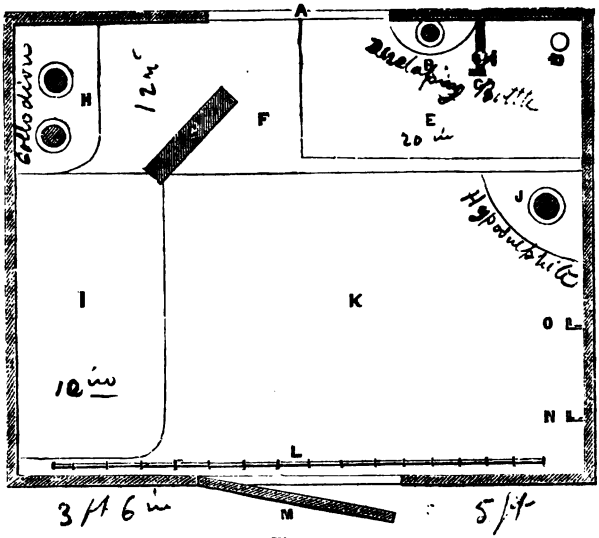


Fig. 65.

Preparing the Glass.—As everything depends on a clean glass, I adopt this mode of preparation, which differs somewhat from that recommended by Mr. Hardwich:—I mix up some Tripoli powder or whiting, with one part liquor ammonia, two parts alcohol, and three parts water; dip a piece of clean cotton wool into this mixture, and proceed to cover the surface of a glass plate already washed and dried. Do this in circles, and with some degree of force at first, leaning less weight as you are about to finish; treat half-a-dozen or more glasses in the same way. Put them to dry with their faces (the surface covered with the Tripoli, &c.) next the wall, and when dry take a second piece of cotton-wool, and by briskly drawing it over the surface remove the dry dust left on the latter by the evaporation of the Tripoli mixture, and from off the edges also; then take another clean and *dry* piece, and finish off with the greatest care. As each is finished, place it in a box with grooves, and take care that the faces are all in the same direction. I should recommend the clean side towards the back of the box or from you, because, if you should not have an empty box, you would place them resting on the collodion shelf with the *clean side next the wall;* then filter your bath of nitrate of silver, the developing solution, and the collodion (the latter must be filtered through a papier Joseph). It will answer as well, in most cases, if the collodion is gently decanted from the bottle, holding it into another (previously washed out with a small quantity of ether), keeping back the bottom portion, which will contain any portions of undissolved cotton, &c., that may be present. The collodion should have been mixed some hours before use; if even a day it would be all the better.

Coating the Glass.—Supposing now that you are about to operate, you will proceed as follows:—Go into the dark-room, and wash out the glass you intend to use for

developing. A glass called a precipitating glass, such as is here figured (Fig. 65), is the best for this purpose. Put the requisite amount of developing solusion in it; then take the bottle holding the collodion that you intend to use, and, taking out the stopper, insert very carefully the point of one of your fingers so as to remove any portion of dry collodion that may remain there. Take care th at there is not any more remaining about the neck or body of the bottle, or anything else that might fall on the glass plate. Taking a glass plate on a holder, or, what is far better, the tips of the fingers of the left hand, pour gently, and without any *haste* or *flurry*, a sufficient quantity of collodion on its clean surface. There are many methods of doing this, but the most successful that I know of is to pour the collodion on the plate thus (premising that you are holding the glass on the fingers of the right-hand as in Fig. 64):—Commence at A (Fig. 67), and as you pour on the collodion, allow it, by inclining the glass, to take the course pointed out by the line proceeding from A to E. In doing this, do it slowly and evenly, and recollect that it is not necessary to allow, or, more properly speaking, to wait, for the collodion to run right up to the corner, for when it arrives near B, that corner of course will be the lowest; but in altering the inclination so as to cause it to flow towards C, we do not raise B but depress C until B and C are about equal; that being the case, the *side* of the plate between B and C becomes the lowest, and by the time the collodion arrives near the corner C, it will have flowed fully up to B; the same action takes place between C and D, and so on. The advantage gained is, that the collodion never flows *back again* over a part *already coated*.

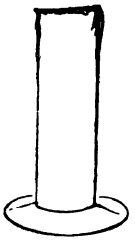


Fig. 66.

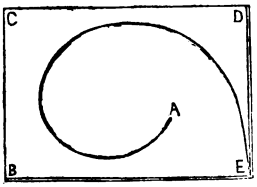


Fig. 67.

The Nitrate Bath.—By a little practice the reader will be able to coat any sized plate. Return the surplus collodion into the bottle from E, rapidly sliding the fingers up to C, E resting on the mouth of the bottle, and thus preventing any unequal evaporation from the parts which would be otherwise over the points of the fingers; and when the collodion has nearly all run off, move the plate backwards and forwards a few times, so as to prevent the formation of any lines in the film of collodion; in other words, change the position of the plate from Fig. 68 to Fig. 69. When the collodion ceases to drop, and the film becomes pretty well set, place the plate on the dipper, and (having previously skimmed the surface of the nitrate of silver solution in the bath with a small strip of blotting-paper) proceed to immerse the dipper and plate slowly and evenly, recollecting that if you make a stop or hesitate for a moment, you surely spoil the plate. The latter once in the exciting bath, leave it there and carefully wipe out the slide, then covering the bath

Fig. 68.

Fig. 69.

with a light-proof cover, open the door of the dark-room, and proceed to focus and arrange the sitter or object to be copied.

The plate may be coated with collodion and immersed in the bath without the necessity of having the door of the dark-room closed, as the sensitive iodide of silver is not formed on the instant of immersion; but in this case it will be necessary to cover the bath with a light-proof cover, or to shut the door immediately.

Placing in the Camera.—Having obtained the proper focus and adjustment of the object to be copied, put the cap on the lens, and remove the ground glass, then, going into the dark room close the door, and draw the curtain. If a minute at least has elapsed since the immersion of the plate, draw it out of the bath, and examine the surface to see if all greasiness has disappeared, otherwise the plate will be all mottled and streaky. When the surface of the plate appears smooth and even, dip it and withdraw it two or three times afterwards. Then allow it to drain for nearly a minute, allowing it to become nearly dry, and never attempting to take a collodion picture while the plate is dripping; —this is an essential point, and should be strictly attended to if a good picture be desired. When the plate has been sufficiently drained, place it carefully in the dark slide; placing the slide gently in the camera, pull the shutter up quietly, and uncover the lens for the proper time. Take especial care not to push the shutter down with a bang, or with force, that being sure to cover the plate with spots and stains. I have seen an amateur hitting and thumping the shutter of his dark slide when it stuck from being swollen by wet, or some other cause, and I need scarcely add, that the resulting picture was a brilliant specimen of spots and messes. In fact, every operation in the collodion process should be performed as if you were working in the den of a sleeping tiger!

Developing.—Upon entering the dark-room with the exposed plate, previous to development, gently shut the door and draw the curtain (it is better to have the curtain tacked permanently across the inside of the door, and without plaits—in this case it must be pushed on one side when entering or leaving the dark-room), then place the slide, leaning against the wall, on the left hand, taking care not to knock it, and looking round to see if your developing glass contains the required solution, and that everything else is ready; take out the back of the slide, and holding the upper part of the latter in the left hand, lean it gently over until the excited plate falls out against the thumb and spread fingers of the right, placed in a proper position to receive it. By lowering the hand, the plate becomes level, and may be lifted away from the dark slide at once on the tops of the fingers. You next proceed to transfer it to the left hand, and take up the developing-glass in the right; then slowly, and without hurry, but at the same time evenly and without hesitation, commence to pour the solution on the surface of the plate; this will require no little practice, and should be done in such a manner that the plate will be just covered by the time all the solution has left the glass—the former should flow evenly over from end to end. To cover a large plate well, proceed thus:—Let the corners A B be lower than C D, but in the same horizontal line in the direction from A to B, or looking at the side of the plate (Fig. 70), then commence to pour on to the plate at C, and draw the glass backwards and forwards as you go down the plate (Fig. 71). It will not be necessary to go over

Fig. 70.

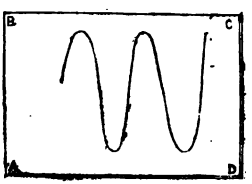


Fig. 71.

more than half the plate with the developing glass, as the amount of liquid will by that time have flooded the whole. Then, by moving the hand and fingers, cause the liquid to flow from end to end, and from side to side, pouring it back into the glass and on to the plate again, until the desired amount of intensity and development are obtained; this may be ascertained by looking through the plate when the developing solution has been poured back into the glass.

When fully developed, wash it well before using the fixing agent. This is the more necessary when hyposulphite of soda is employed, as that salt would be decomposed by the presence of the acetic or other acid used, and by throwing down sulphur injure the brilliancy of the negative. After all traces of the iodide of silver have disappeared, the plate must then be well washed with plenty of water, covering it fully each time, swilling it about on the surface for a few moments, and pouring it off again; then set it up to dry. The lower edge should rest on a strip of blotting-paper. When dry, examine it for a sort of whitish powder, something like frost; should this appear on the surface, it is owing to the presence of hyposulphate of soda, and shows that the plate was not sufficiently washed. Should the plate be perfectly free from any such appearance, it may then be varnished. This is done by slightly warming the plate, covering the surface with varnish as you did with collodion, and, returning the excess to the bottle, holding the plate to the fire until it dries without chilling. The negative, or positive, is now finished, and by carefully following the preceding directions, a good picture should be the result; but if not, we must endeavour to find out the cause.

Mr. Hardwich's Formulæ.—These remarks on the manipulation which has been adopted in Mr. Fenton's establishment I would have followed by my own formulæ for preparing each of the solutions required, but Mr. Hardwich has treated this branch of the subject so fully and so ably in his "Chemistry of Photography" that I willingly avail myself of his permission to quote this and other portions of his book; and I do so the more readily as it would be nearly a matter of impossibility for me to do the subject justice otherwise than in his own words. That the reader may understand my meaning more fully, I may quote the passage from the preface to Mr. Hardwich's work, in which he mentions my connection with his experiments. "*I am also indebted,*" he says, "*to Mr. Sparling for repeating many of my experiments upon a larger scale, and carefully chronicling the results.*" Such being the case, I can scarcely do otherwise than give the formulæ, the result of these experiments, in Mr. Hardwich's words, while I acknowledge his courtesy in granting me permission to do so.

As there is much difficulty in ascertaining the proper strength of the materials employed, Mr. Hardwich goes at considerable length into the question, and in a future page I may give the substance of his researches. His formulæ we shall quote in the order in which he gives them:—

"FORMULA FOR SOLUTIONS FOR DIRECT POSITIVES.—The solutions are taken in the following order:—The collodion; the nitrate bath; developing fluids; fixing liquids; whitening solution.

"*The Collodion.*

Purified ether, sp. gr. ·720	5 drachms.
Purified alcohol, sp. gr. ·825	3 ,,
Pyroxyline	2 to 3 grains.
Pure iodide of ammonium	2 grains.

Or,	Rectified ether, sp. gr. ·750	6 drachms.
	Spirits of wine, sp. gr. ·836	2 „
	Pyroxyline	2 to 3 grains.
	Iodide of potassium	2 to 3 „

"The exact quantity of pyroxyline required cannot be stated, since some samples produce a more glutinous solution than others. The rule is to keep the texture of the film slight. If the quantity specified yields a solution fluid like water, and running down the neck of the bottle in the attempt to pour it on the plate, it may be increased.

"The appearance of the film, after dipping in the bath, is a guide to the proper quantity of ingredients; it should be blue and transparent. If it is pale, increase the quantity of pyroxyline, at the same time with that of the iodide.

"The iodides of potassium, ammonium, or cadmium may be used. Collodion iodized with the cadmium salt possesses great keeping qualities; but the writer prefers the alkaline iodides, and especially the iodide of ammonium, if it be pure. Iodide of potassium does not dissolve in quantity greater than two grains to the ounce if the ether and alcohol are highly rectified.

"With regard to the length of time this collodion can be kept in working order, everything will depend on the condition of the ether. If recently distilled, probably the colour will scarcely have passed the orange-yellow stage at the expiration of a fortnight, or even with iodide of potassium three weeks or a month. A lemon-yellow tint does no injury to the most delicate film, but when the colour reaches to a decided brown, the iodine may be removed.

"The writer does not, from experience, advise keeping a stock of the dilute collodion *uniodized* for more than a month or six weeks; the tendency to decomposition in the ether seems to be increased by the solution of the pyroxyline.

"Many operators take positives with a more highly iodized collodion intended for negatives, adding nitric acid to the bath, if the intensity is too great. This process is likely to yield pictures very clear and free from fogging, but is less sensitive than that just described, and often gives the shadows dark and sombre.

"*The Nitrate Bath.*—It is necessary to saturate this solution with iodide of silver, and to remove any free nitric acid which may be present. Therefore, having weighed out the following quantity of crystals of nitrate, &c., for the bath, viz.:—Nitrate of silver, crystallized *and dried*, but not fused, 25 grains; acetic acid (glacial), ½ minim; distilled water, 1 ounce; dissolve in about two parts of water. Then take iodide of potassium or ammonium, half a grain to each 100 grains of nitrate, dissolve in half a drachm of water, and add to the strong solution; a yellow deposit of iodide of silver first forms, but on stirring is completely redissolved. When the liquid is clear, drop in a solution of potash or carbonate of soda until a distinct turbidity, not removed by agitation, is produced (an excess does no harm); then dilute down the concentrated solution with the remaining portion of the water, stirring all the time, and filter out the milky deposit. If the liquid does not at first run clear, it will probably do so on passing it again through the same filter.

"Ammonia may also be used to neutralize free nitric acid, but it must be added very cautiously, or a quantity of oxide of silver will be dissolved, forming with the acetic acid, advised in the formula, acetate of silver *in excess*, which is injurious in a positive nitrate bath.

"After using any alkali or carbonate, the bath is left in a faintly alkaline con-

dition, and unfit for use until the acetic acid has been added. If the *glacial* acetic acid be employed, it should be tested for impurities.

"Many, unaccustomed to chemical manipulations, may desire to avoid the trouble of saturating the bath with iodide of silver, and of removing the free nitric acid; in that case make it a little stronger than the formula, thirty grains to the ounce, omit the acetic acid, and remove the sensitive plate as soon as the layer of iodide of silver is formed.

"If the operator uses a collodion somewhat thicker than that recommended; or if large bluish patches of non-development occur in bringing out the image, the strength of the bath may be increased to thirty or thirty-five grains to the ounce.

"With regard to the length of time the bath will remain in working order no positive opinion can be given. If it begins to yield foggy pictures, try the effect of nitric acid, one minim to the half-pint of solution.

"The addition of alcohol to a positive nitrate bath is not recommended.

"*The Developing Fluids.*—Either of the three following formulæ may be used, according to the taste of the operator.

Formula No. 1.

Sulphate of Iron, recrystallized	12 to 20 grains.
Acetic Acid (glacial)	20 minims.
Alcohol	10 minims.
Water	1 ounce.

Formula No. 2.

Pyrogallic Acid	2 grains.
Nitric Acid	1 drop.
Water	1 ounce.

Formula No. 3.

Solution of Protonitrate of Iron	1 ounce.
Alcohol	20 minims.

"*Remarks upon these Formulæ.*—*Formula No.* 1 is the most simple, since the solution can be used as a bath, the same portion being employed many times successively. If it acts too rapidly, lessen the proportion of sulphate of iron. An addition of nitric acid, half a minim to the ounce, makes the image whiter and more metallic; but if too much is used, the development proceeds irregularly, and spangles of silver are formed.

"The Alcohol and acetic acid render the development uniform by causing the solution of protosulphate to combine more readily with the film. The latter also has an effect in whitening the image and increasing its brightness.

"Solution of sulphate of iron becomes red on keeping, from a gradual formation of *persalt*. When it is too weak, add more of the protosulphate. The muddy deposit which settles to the bottom of the bath is metallic silver, reduced from the soluble nitrate upon the plates.

"Some operators add nitrate of potash to this developing solution (it must be pure nitre and free from chloride), so as to form a small portion of protonitrate of iron. It is said to improve the colour slightly. The proportions are ten grains of nitrate of potash to about fourteen or fifteen grains of protosulphate of iron.

"*Formula No.* 2.—In this formula, if the colour of the image is not sufficiently white, try the effects of increasing the amount of nitric acid slightly. On the other

hand, if the development is imperfect in parts, and patches of a green colour are seen, use three grains of pyrogallic acid in place of two, with less nitric acid. Supposing this not to succeed, a few drops of nitrate of silver solution added to the pyrogallic, immediately before use, will augment the energy of development.

"*Formula No. 3*, or protonitrate of iron, does not require any addition of acid; but it will be advisable, in some cases, to add to it a few drops of nitrate of silver immediately before developing. This gives a bright metallic image, resembling that obtained by adding nitric acid to protosulphate of iron.

"The following are the processes commonly followed for preparing protonitrate of iron:—

"1st, *By the Action of Dilute Nitric Acid upon Sulphuret of Iron.*—Dilute an ounce of nitric acid with six ounces of water, and add to it about half an ounce of sulphuret of iron, previously broken into very small fragments. Set the vessel aside for several hours, in a place where the offensive and poisonous sulphuretted hydrogen gas may escape without doing injury. When all effervescence has ceased, pour off the green solution, add to it twenty grains of powdered chalk or whiting, and boil it in a flask for five minutes. Allow it to cool, and filter from it the black deposit, if any has formed. In this process the nitric acid, being in a diluted state and employed cold, does not act as an oxidizing agent, but simply displaces sulphuretted hydrogen and forms protonitrate of iron. The chalk is added in order to neutralize a small portion of free nitric acid, which commonly remains after the action is complete. If a black deposit is noticed on boiling, it is sulphuret of iron produced by the excess of sulphuretted hydrogen, dissolved in the liquid, again reacting upon the protosalt of iron as the solution becomes neutral.

"2nd, *By Double Decomposition.*—This plan is somewhat less economical than the last, but probably superior to it in most other respects. Take of nitrate of baryta three hundred grains; powder and dissolve by the aid of heat in three ounces of water. Then throw in by degrees, with constant stirring, crystallized sulphate of iron powdered, 320 grains. Continue to stir for about five or ten minutes. Allow it to cool, and filter it from the white deposit, which is the insoluble sulphate of baryta.

"In place of nitrate of baryta, the nitrate of lead may be used (sulphate of lead being an insoluble salt), but the quantity required will be different. The atomic weights of nitrate of baryta and nitrate of lead are as 131 to 166; consequently 300 grains of the former is equivalent to 380 grains of the latter.

"*The Fixing Solution.*—Cyanide of potassium, two to twelve grains; common water, one ounce.

"Cyanide of potassium is usually preferred to hyposulphite of soda for fixing direct positives; it is less liable to injure the purity of the white colour. The per centage of carbonate of potash in commercial cyanide of potassium is so variable, that no exact directions can be given for the formula. It is best, however, to use it rather dilute—of such a strength that the plate is cleared gradually in from half a minute to a minute.

"The solution of cyanide of potassium decomposes slowly on keeping, but it will usually retain its solvent power for several weeks. In order to escape inconvenience from the pungent odour evolved by this salt, many employ a vertical bath to hold the solution; but in that case the plates must be carefully washed before fixing, as the iron salts hasten the decomposition of the cyanide.

"*The Whitening Solution.*—Bichloride of mercury, thirty grains; distilled water, one ounce.

"By a gentle application of heat, the corrosive sublimate dissolves and forms a solution as nearly as possible saturated at common temperatures. The addition of a portion of muriatic acid enables the water to take up a larger quantity of bichloride; but this concentrated solution, at the same time that it whitens more quickly than the other, is apt to act unequally upon different parts of the image.

"Before applying the bichloride, the image is to be fixed and the plate well washed. Either the protosulphate of iron or the pyrogallic acid with acetic may be used for the development; but the whitening process is more rapid and uniform in the latter case, the metallic particles being more finely divided.

"FORMULÆ FOR NEGATIVE SOLUTIONS.—*The Collodion.*—In making negative collodion the writer has succeeded best with pyroxyline prepared from paper (strips or squares of paper cut into small pieces, and dissolved in sulphuric acid and nitre, and washed in pyroxyline), which seem, from some unknown cause, to give more intensity than cotton. If the following solution is very fluid with three or four grains of pyroxyline to the ounce, as is often the case when the temperature of the nitro-sulphuric acid was high, it is useful to add a grain or so of a glutinous sample made from cotton, by which the requisite degree of viscidity is obtained. In this way, by combining the two, a collodion may be made which will yield excellent half-tones with any amount of intensity.

	Purified ether, sp. gr. ·720	5 drachms.
	„ alcohol, sp. gr. ·825	3 drachms.
	Soluble pyroxyline	3 to 6 grains.
	„ iodide of ammonium	3 to 4 grains.
Or,	Rectified ether, sp. gr. ·750	6 drachms.
	Alcohol, sp. gr. ·836	2 drachms.
	Soluble pyroxyline	3 to 5 grains.
	Iodide of potassium	4 to 5 grains.

"The film of iodide when formed in the bath should be tolerably dense, and more pyroxyline must be added to the collodion if it is blue and transparent; this increases the opacity better than an addition of alkaline iodide, the quantity of which should never exceed four, or at most five grains to the ounce.

"If the collodion is glutinous, and produces a wavy surface, with less than four grains of pyroxyline to the ounce, it is probable (unless the alcohol employed is inferior) that the soluble cotton was badly made. In that case, try Mr. Shadbolt's formula of adding of chloroform ten drops to each ounce of the fluid, and set it aside for twenty-four hours.

"In place of iodide of ammonium, in the first formula, a mixture of iodide of potassium and ammonium, or of potassium and cadmium, may be used; the former is especially recommended.

"If flakes of iodide of silver are seen loose upon the surface of the film, and falling away into the bath, the collodion is over-iodized, and it will be impossible to obtain a good picture.

"After the collodion has been employed to coat a number of plates, the relative proportions of alcohol and ether contained in it become changed, from the superior volatility of the latter fluid. Therefore, when it ceases to flow readily, and gives a more dense film than usual, thin it down by addition of a little rectified ether.

"Most operators adopt the plan of keeping on hand a stock of the plain collodion,

and iodizing as required by the addition of alcoholic solution of iodide of potassium. The plain collodion, however, does not keep well beyond a certain length of time without a considerable development of the acid principle.

"In dissolving the pyroxyline, any fibrous or flocculent matter which resists the action of the ether must be allowed to subside, the clear portion being decanted for use. The iodide of potassium is to be finely powdered, and digested with the spirit for several days; if a saturated solution is required, it is better not to apply any heat. Both iodide of ammonium and iodide of cadmium should dissolve almost immediately, if the salts are pure.

"When this collodion becomes very highly coloured and insensitive, a part of the free iodine may be removed by a strip of pure zinc or silver foil; also the metallic powder obtained by reducing nitrate of silver with sulphate of iron acidified with nitric acid, answers well for the same purpose.

"Many operators, where sensitiveness is not an object, prefer working with an old collodion, thinking that it gives more intensity combined with half-tone. The latter part of this rule, however, is not universal, for if the quantity of iodide of silver in the film is small, the half-tones are best at the lemon-yellow stage of colouration. It is certain that some peculiar change takes place in collodion after iodizing, by which the intensity of the image is increased; and it is probable that this may be independent of colouration, for the author has observed that a grain or two of fresh iodide, added to a sample in excellent working order, immediately diminishes the intensity although the excess of free iodine remains the same.

"*The Nitrate Bath.*

Nitrate of silver, crystallized and dried . . .	30 grains.
Acetic acid (glacial)	¼ minim.
Distilled water	1 ounce.

"This bath is first to be saturated with iodide and carbonate of silver, and the acetic acid is to be added subsequently.

"A negative nitrate bath, carefully shielded from the light, will remain in working order for many months. The proportion of nitrate of silver present becomes less after a time, but not to the extent that might *à priori* be imagined. About five grains of fresh nitrate per ounce will restore it to the original strength, even after a large number of plates have been coated.

"If a very brown sample of collodion is constantly employed, and the appearance of the negatives (misty and pale, greenish by transmitted light) leads at last to a suspicion of free nitric acid beginning to accumulate, add a single drop of ammonia to the half-pint of solution. The operator, however, should bear in mind that if the bath was neutralized when first prepared, it will take many ounces of brown collodion to liberate a perceptible quantity of free nitric acid in a twelve-ounce solution, and it is always better not to add an alkali, unless really required.

"*The Developing Solution.*—The quantity of acetic acid required in the following solution will vary with the strength of the acid and the temperature of the atmosphere. An excess enables the manipulator to cover the plate more easily before the action begins, but gives a bluish, inky hue to the image. In cold weather, use less acid and more free nitrate of silver in the developer:—

Pyrogallic acid	1 grain.
Acetic acid (glacial)	10 to 20 minims.
Alcohol	10 minims.
Distilled water	1 ounce.

"If the image cannot be rendered sufficiently black, two drops of the nitrate bath solution may be added to each drachm towards the end of the development.

"Also, the proportion of pyrogallic acid may, if required, be increased to two or even three grains to the ounce.

"If the solution be kept for some time after its first preparation, it is apt to become brown and discoloured. In order to avoid this, it has been recommended to make it about four times more concentrated than is necessary, and to dilute down with distilled water when required for use.

"*The Fixing Liquid.*—For remarks on the cyanide of potassium fixing bath see page 214.

	Cyanide of potassium	2 to 12 grains.
	Water	1 ounce.
Or,	Hyposulphite of soda	½ ounce.
	Water	1 ounce."

Defects and Remedies.—I have now to call the reader's attention to the failures he is pretty certain to meet with in his first attempts at photography, pointing out at the same time the usual causes, as far as they can be traced, and their remedies. In this study, however, as in all others, the operator must think for himself, and try to discover the causes of failure, as well as the required remedies, for it is not to be expected that they can all be foreseen in a treatise like the present. Among other annoyances, a number of small white or transparent spots in the negative will present themselves, caused by plunging the plate too rapidly in the nitrate bath, or dashing the developing solution too rapidly over the surface of the plate; in either case a number of minute air bubbles have been formed, which no after manipulation can remove or bring up to the same degree of intensity as the surrounding portions of the plate.

The plate blackens all over when the developing solution is used. This arises from many causes, viz., the plate may have been exposed accidentally to white light during some part of the process, or the camera or dark slide may admit light; this must be ascertained. Or it may be owing to over exposure; in this case the picture will be clean, but very feeble, and all the details may be made out. This may be very easily detected from another cause of blackening, owing to the bath or collodion being *alkaline* in a slight degree, and well known by the term "fogging." In this case we obtain an even black all over without the slightest trace of a picture. Should the blackening be owing to any of the causes named except the last, the cause at once suggests the remedy. If by the last named, it may be remedied by adding a drop or two of acetic acid to the nitrate of silver bath, or five or ten drops of tincture of iodine to the collodion. The latter must be done if the bath does not change slightly reddened litmus-paper into blue. Instead of adding the acetic acid to the bath, if you have time to expose it to the sun for some hours in a white glass bottle, it will be the safer way of bringing it back again. Should the blackening be of an irregular description, more on one part of the plate than another, it will probably arise from the rays of the sun shining nearly into the lens, or from some light reflected from the edge or

inside tube of the lens, all which it will be necessary to look for in order to remedy the defect.

There are other means used to neutralize the acid bath. Mr. Hardwich recommends that the ammonia should be used in a very dilute state; but I think the use of ammonia in any shape very injurious. A writer in the Photographic Journal recommends a piece of rough white marble to be suspended in the bath by means of a piece of thread for a few days. Another recommends the addition of a few drops of dilute solution of caustic potash. That I also think objectionable. By far the best, simplest, and most successful plan, and one which I have used for some time, and which will succeed best in the hands of the amateur, as he cannot very well overdo it, is to scrape a small piece of pipe-clay or whiting into the bath, as much as will go on a sixpence to the pint; this effectually neutralizes the nitrate bath, which may be used immediately after being filtered.

Mr. Horne recommends a very good plan for restoring the bath when it becomes out of order through excess of iodide of silver in solution. He directs that a portion of pure distilled water should be added, say four ounces to a bath containing twenty or thirty ounces; this will precipitate the iodide, or a great part of it. The bath must then be filtered, and to it be added two drachms of nitrate of silver in crystals. The bath will then be in first-rate working order.

I shall again impress upon the amateur that nothing will neutralize an acid bath so well as a small piece of pipe-clay or whiting. In testing with litmus-paper after the addition of the whiting, &c., the test-paper will appear purple; but this will be owing to the carbonic acid, and will disappear if the paper be pressed between blotting-paper and dried at the fire. Chalk, being of the same nature as whiting (carbonate of lime), will answer quite as well.

Spots of black, printing white on the positive, more especially at the bottom of the latter. These are caused by dust, want of care in closing the shutter—viz., shutting it down with a bang—dirty developing glass, allowing drops of decomposed solution to fall on the plate from the bottom of the developing glass, or other piece of carelessness. The causes must be sought for by the amateur, and as they are always caused by careless manipulation, he must find out the remedy himself. There is an appearance often noticed in positives and negatives—in the one black, in the other white—similar to snow melting and freezing again into icicles, at the bottom of the picture; this is always caused by the top part of the plate-holder not being well wiped dry before the introduction of the plate; but, in some cases, the same appearance *almost*, but at the *top* part of the *positive*, takes place. This is generally caused by the plate being allowed to stand so long that the surplus solution of nitrate of silver drains off the surface of the plate, and accumulating at the end of the plate, which would be downwards at the time (the top in the positive), after being decomposed by contact with the surface of the plate-holder, reascends by capillary attraction. This is easily known by wave-like markings appearing at the *top* of the *positives*. These markings may be prevented by placing a slip of blotting-paper at the bottom part of the plate, on the back and lowest edge, when placing it in the dark slide; or merely placing a narrow strip in the bottom of the latter will do as well.

A black spot in one corner of the negative, about the size of a shilling, with several short lines from it, printing white in the positive. This is always produced by the contact of the finger with the excited plate, more especially if the finger has had on it the least trace of hyposulphite of soda.

Avoid the cause, and bear in mind that the fingers will always cause stains wherever they touch the surface of any photographically prepared plate or paper; and the fingers of some persons more than others, owing to the degree of moisture, holding chlorides, &c., in solution, they may possess.

Halo Light.—The positive has a sort of halo of light about the centre of the picture. The same appears in the negative, but reversed, i.e., black; at the same time, there is a want of distinctness.

This is caused by reflected light in or from the lens. To ascertain the cause it will only be necessary to remove the ground glass, leaving the lens uncovered, place the focusing-cloth over the camera and look at the lens, when you will see an immense quantity of light reflected from its edges. This may be remedied by a very narrow diaphragm, or, what will do as well, a narrow streak of black varnish painted round the outside rim of the lens. It is a most curious fact, that some of our best lens makers, will not take any pains to remedy this defect, although it has been often pointed out to them; and, I may add, that I have never seen a lens without this defect more or less. The streak of black varnish, or the diaphragm, need not be wider than an eighth of an inch, just sufficient to cut off the light reflected from the edge of the lens. In double lenses used for portraiture there should always be a diaphragm between the front and back lens.

Irregular oily looking lines and spots resembling marble paper, or the appearance caused by attempting to cover a greasy surface with water. These are always to be traced to one of the following causes:—

Raising the plate out of the bath before it has been sufficiently long immersed (a minute at least); removing the plate too soon from the bath or before the ether has been washed away; re-dipping the plate after exposure (which should never be done), and proceeding to develop before the nitrate has been well drained off the surface; or reversing the plate from the position in which it was taken out of the bath, causing the silver solution to flow back again in lines, thus producing irregular action in the development.

Transparent spots and streaks are caused by impure ether, pouring the developing solution on the one spot, dirty glasses, more especially when the collodion is thin and the bath neutral. These more frequently occur when the glass is colder than the air in the room, the latter becomes condensed on the surface of the glass, which should not be covered until the moisture has evaporated again. When those spots are owing to some fault in the collodion, they may always be seen on the plate before exposure; and should any occur in an important part of the plate, it would be better not to use it. A reticulated appearance of the film is owing to impure alcohol or ether used in making the collodion, or to immersing the plate in the bath too quickly after being coated with collodion. One or two straight lines across the plate, transparent or nearly so, are caused by checking the plate in immersing it in the nitrate bath.

Irregularly-curved or circular black lines, separating a dark portion of the plate from another not so intense, are caused by not pouring on the developing solution evenly; for if you allow it to stop for a single instant on any one part of the plate, it will surely cause a line. There is a very nice arrangement for applying the developing solution, especially the protosulphate of iron. It is as follows:—A gutta-percha bath is made, part of which returns at right angles, or nearly so (Fig. 71), in which the plate A is shown resting against the back of the upper part C, C, C, on two

small pieces or blocks of gutta-percha; the bottom part, B, B, holds the developing solution, and by turning it down (Fig. 72) the solution flows evenly over the surface. The same sort of bath will answer very well for the nitrate of silver bath. It should not be made at right angles, as the plate will rest more safely to drain, &c., when the bath is turned up again if it be made thus (Fig. 73). As the collodion dries round the neck of the bottle, it will be necessary to remove it carefully with the finger, previously to coating each plate, otherwise it will fall and spoil the film. When the collodion is too thick it will not flow evenly off the plate, and cause a cloudy irregular surface; it must then be thinned by adding ether *alone*, as the latter has evaporated in greater quantity than the alcohol.

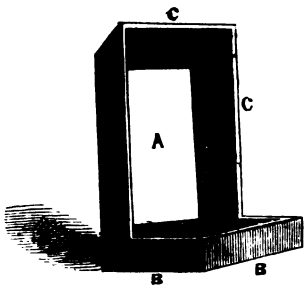


Fig. 71.

If, after a reasonable exposure in a good light, the negative is intensely black and white, with absence of half-tone, the bath is too acid, and must be neutralised by carefully adding a small quantity of ammonia-nitrate of silver solution, made by adding liquor ammonia to a solution of nitrate of silver, drop by drop, until the brown precipitate first formed be redissolved. The portions added to the nitrate bath should be very small indeed, and the bath tried after each addition. If so much be added as will cause fogging, then you must add a drop or two of acetic acid. All this must be done very carefully, or you will surely *spoil the bath*. The more acid the bath, the longer will be the exposure required; but amateurs will succeed better with a *slightly acid bath* than with a *perfectly neutral one*, the latter requiring much more care and delicate manipulation than the former; but the *neutral bath will always produce the finest photographs*. *Under-exposure* and *over-development* will produce effects almost similar to an acid bath.

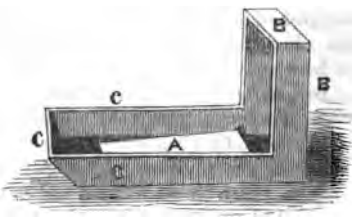


Fig. 72.

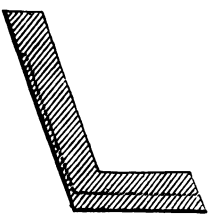


Fig. 73.

As collodion loses its sensitiveness when dry, there have been several methods thought of for preserving it moist for a considerable length of time; but I am inclined to give the preference to the plan proposed by Messrs. Spiller and Crookes, as I have taken a picture in that manner three days after the plate was made sensitive. They take advantage of the property possessed by certain "deliquescent" salts, which remain moist for any length of time when once melted; and many of them absorb moisture so eagerly from the air, that it cannot be easily driven off except by considerable heat. Nitrate of zinc and acetate of potash were the salts originally selected, but nitrate of magnesia has been substituted. Messrs. Spiller and Crookes' process is as follows:—

"The plate, coated with collodion in the usual manner, is to be rendered sensitive in a thirty-grain nitrate of silver bath, in which it should remain rather longer than

is generally considered necessary (about five minutes); it must then be slightly drained and immersed in a second bath, consisting of

Nitrate of magnesia	4 ounces.
Nitrate of silver	12 grains.
Glacial acetic acid	1 drachm.
Water	12 ounces.

And there left for about five minutes, then removed and placed in a vertical position on blotting-paper, until all the surface-moisture has drained off and been absorbed. This generally takes about half an hour, and they may then be packed away in any convenient box until required for use.

"Not only is the sensitiveness unimpaired by this treatment, but we think, on the contrary, that it is slightly increased; instantaneous negatives have been taken on plates which had been prepared some days previously. We are not yet in a position to give the length of time that may elapse between the preparation of the plate and development of the picture; such experiments necessarily require a more lengthened period than we have at present been able to give, but as long as they have yet been kept (upwards of three weeks) there has been no appearance of deterioration.

"Before the development, we find it advisable to moisten the collodion film by immersion in the silver bath for about half a minute, as otherwise the pyrogallic acid or iron solution would not flow evenly over the plate. The fixing, &c., is of course conducted as usual.

"It will be as well to draw attention to a few points which, although not absolutely essential, may possibly be found useful in practice. The glass plates should be cleaned with more care than is necessary when they are to be used immediately; we have found strong nitric acid applied with a tooth-brush most convenient. With regard to the collodion, we have tried many different samples, and with tolerably uniform success. The greater number of our experiments have been made with a tolerably thick collodion, the alcohol and ether of which were in the proportion of 1 : 2, made sensitive with four grains of iodide, and half a grain of bromide of ammonium to the fluid ounce. We have also employed a collodion containing iodide and bromide of cadmium with good success.

"Of the thirty-grain silver solution for exciting the plate, we have only to recommend the use of acetic instead of nitric acid, to give the bath that faintly acid reaction which is by some operators considered desirable.

"There are one or two circumstances to be attended to in the preparation of the magnesia bath. Commercial fused nitrate of magnesia is very liable to contain chlorine, and also to have an alkaline reaction on account of the fusion being carried too far. Of course the quantities of acetic acid and nitrate of silver given in the formula for the bath, are on the supposition that the nitrate of magnesia is pure; if this be not the case, it should be rendered perfectly neutral with acetic acid, the chlorine exactly precipitated with nitrate of silver, and then the proper amounts of acid and silver added. However, if the impurities are very considerable, it will be safer to reject the salt at once. This bath will keep in good order for a long time; the only point to be attended to is to drain the plates slightly after coming from the silver bath, and, if necessary, to remove the liquid from the back with blotting-paper, so as to introduce as little silver as possible into the nitrate of magnesia. A solution of one grain of silver to the ounce is quite sufficient to keep the plates sensitive; and when the

strength rises, as it will in time, to above a certain limit, the slight evaporation that always takes place will render the silver solution sufficiently strong to dissolve off the iodide in small holes. If this occur, the bath can be restored by nearly, but not quite, precipitating the silver with a solution of chloride of magnesium, and then filtering.

"One of the most important things to be attended to is, the necessity of preserving the plates where they are perfectly free from any light. It will be evident to all, that anything short of absolute darkness, when the sensitive surface is exposed to its action day after day, and perhaps week after week, must be fatal to its subsequent cleanliness. The necessity for protecting the plates from any deleterious gases—ammonia, for instance—is too obvious to require comment."

As it is not very easy to obtain the nitrate of magnesia pure enough for photographic purposes, the following observations by Mr. Hardwich may be interesting here:—

"*Nitrate of Magnesia.*—Nitrate of magnesia may be prepared by dissolving magnesia or its carbonate in dilute nitric acid. It crystallizes with difficulty in rhomboidal prisms, which are deliquescent and soluble in an equal weight of water. When intensely heated, it loses both water and acid, and magnesia remains.

"Commercial nitrate of magnesia usually contains chloride of magnesium, and if it has been strongly fused, nitrite of magnesia and oxide of magnesium; it will be better, therefore, to prepare it purposely for photography.

"A solution of nitrate of magnesia, of about the strength recommended by Mr. Spiller for preserving the sensitiveness of collodion plates, may easily be obtained as follows:—Take five fluid ounces of a colourless sample of nitric acid of the common strength, sold at about tenpence per pound (specific gravity, 1·36 to 1·4), and dilute it with seven ounces of water; then weigh out carbonate of magnesia four ounces, and add it by degrees until all effervescence has ceased, and an excess of magnesia remains, rendering the liquid milky. Next add the nitrate of silver recommended in the formulæ, viz., twelve grains, which, however, may conveniently be increased to half a drachm; agitate well until a piece of reddened litmus-paper changes to blue on immersion it in, showing that the bath is alkaline, and then filter from the white deposit and add of glacial acetic acid one drachm, as recommended.

"In this process, the carbonate of magnesia first neutralizes the nitric acid, converting it into nitrate of magnesia; the nitrate of silver decomposes any soluble chloride which may be present, precipitating it in the form of chloride of silver, and also reacts upon the excess of carbonate of magnesia, producing carbonate of silver, which renders the bath alkaline; lastly, the acetic acid removes the alkalinity, leaving in the liquid a trace of acetate of silver, thus giving absolute security against the existence of any free nitric acid, which would destroy the sensitiveness of the preserved plates.

"The solution when completed will usually contain a small quantity of soluble sulphate (evidenced by chloride of barium); the precipitated carbonate of magnesia being rarely washed sufficiently to free it from all traces of sulphate of soda and chloride of magnesium or sodium."

More recently Mr. Shadbolt has proposed to improve the process of Messrs. Spiller and Crookes by using honey instead of the nitrate of magnesia. Although honey cannot be classed with the deliquescent salts, in common with other uncrystallizable sugars, it has the property of remaining moist for a considerable time.

Mr. Shadbolt's process is as follows:—"Having prepared and excited the collodion

in the usual manner, on its removal from the bath of nitrate of silver it is to be drained pretty closely for about half a minute, and then immersed in a second bath, consisting of distilled water twenty to thirty ounces to one ounce of the exciting bath (the exact quantity is not of great moment), and allowed to remain in the latter mixture until the liquid flows evenly on lifting the plate up, which will happen in about from two to three minutes after immersion. The object of this proceeding is to wash away all but a slight trace of free nitrate of silver, as one of the causes of deterioration of the plate is the crystallization of this salt on the surface of the collodion. This distilled water bath should be in a vertical vessel, similar to that used for exciting, and the same bath, if freed from impurities as they accumulate, will do for an indefinite time. To distinguish it, I shall term it the washing bath.

"The plate may be removed from this bath as soon as the liquid flows freely, and again drained closely, when a portion of the preservative syrup is to be poured on and and off once or twice, being careful to avoid bubbles, or any minute particles of matter being left on the plate; which is then to be placed upright upon clean blotting-paper with the collodion-side towards the wall to drain. In about ten minutes' time, the lower edge of the plate where the syrup has been collected, may be touched lightly with fresh blotting-paper to remove the superfluity, and then placed in the dark frame, or stored away in a box for future use. It is not necessary to perform this operation until convenient.

"The preservative syrup is thus made:—Take of pure honey and distilled water equal parts by measure, mix thoroughly and filter. In my former directions a sixth part of the volume of alcohol was included; but further experience leads me to consider this unnecessary, if not detrimental.

"If thoroughly excluded from the action of light, plates thus prepared will keep good for a very long time. The sensibility is certainly less than when fresh plates are used, and I judge that the exposure required is about double the time, for the same collodion, if used immediately after its removal from the nitrate bath; but I cannot detect any further diminution for the first twenty-four hours, and I have taken a picture no less than three weeks after excitation, but with at least four times the exposure required for a fresh plate. I do not, however, recommend the plates to be kept longer than is really necessary, as the chances of change from very little actinic force are certainly great.

"The plates may be developed even as long as twelve hours after exposure. This part of the process is conducted as follows:—

"The plate is to be again immersed in the washing bath and left from one to ten minutes to soak, occasionally lifting it up and down to facilitate the removal of the superfluous syrup, and thoroughly to soften what remains upon the plate. The longer the latter has been kept, the longer it should be allowed to soak.

"When taken out, a sufficient quantity of the developing solution is to be poured over the plate in the ordinary way, and, provided the paper has been properly soaked in the washing bath, there is no greater difficulty experienced in getting it to flow over than when a fresh plate is used. The image should appear very slowly, and when all the details are out but very faintly; the developing solution is to be returned into the measure (taking especial care not to allow the small portion remaining on the plate to run in lines), a feat readily performed if done quickly, and the plate instantly restored to a horizontal position. A small quantity of the exciting bath (a thirty-grain solution of nitrate of silver), from an eighth to a sixth of the volume of the solution that was

poured from the plate into the measure, together with a like proportion of the preservative syrup, should now be added to the liquid in the measure and well mixed up; this is to be poured on the plate and kept moving until the picture is sufficiently intense, which can be carried to any degree if the exposure has been proportionately prolonged. So intense can the high lights be made, that a whole day's exposure to direct sunshine will not print through them. Of course I only mention this to show what can be effected—not what is desirable.

"The developing solution I adopt consists of one grain to the ounce of water solution of pyrogallic acid, one-fourth of the menstruum being the ordinary acetic acid of the druggists, or, if glacial acetic acid is used, one-twelfth part is sufficient."

There have been other suggestions for keeping the collodion plate moist, and therefore sensitive; such as keeping the excited film between two glasses, &c. I fear that they are all of no use; amongst the number, the following promises to be the most successful, but I must add that I have never tried it:—

Captain Caron, of the French artillery, has addressed to the Société d' Encouragement the description of the following process of photography upon dry collodion:—

"The manipulations in the employment of dry collodion are the same as for the moist; the difference lies in the substitution of chlorides for the iodides, which, without exception, lose their sensibility by drying. The chloride of silver is as sensitive in the dry state as when moist; and although its sensibility is not equal to that of moist iodized collodion, it nevertheless remains superior to that of collodion preserved by sugar, honey, mucilage, or salts, which besides have the inconvenience of becoming soiled by dust. The following are M. Caron's preparations:—

"Take of pure collodion three and a-half fluid ounces, add ten, twelve, or fifteen drops of chloride of iodine—as an average, twelve; spread on the glass; plunge in a bath of fused nitrate of silver (forty grains to the ounce), wash with common water; let the glass drain, and dry it. From the dampness of the weather, M. Caron has always dried rapidly at the fire; he is not sure whether this is indispensable.

"Take the impression in the camera or behind a negative. Re-dip the plate in the bath of nitrate of silver for several seconds; develop the image with pyrogallic acid, as for moist collodion; pyrogallic acid fifteen and a-half grains, water ten ounces, acetic acid two and a-half drachms; with the following bath, pyrogallic acid fifteen and a-half grains, water one and a-half pint (imperial), acetic acid two and a-half drachms, the image comes out more slowly, but better. Fix with cyanide of potassium of one five-thousandth ('au cinq millième'); wash, dry.

"The following fact will give an idea of the duration of the exposure:—On a dull day, to print through a negative on collodion, required an exposure of two to three seconds. So long as the image does not acquire a red colour with pyrogallic acid, the exposure has not been sufficient.

"This process is evidently exceedingly simple; and if it gives good impressions, it will be generally adopted. M. Caron says nothing respecting the quality of those that he has obtained; it is true, however, that we are in the midst of winter.

"MM. Duboscq and Tavernier have tried this process, and their results promise much. The collodion applied in this way has all the advantages of albumen, and the drying by the fire appears of great utility."

The process published by Mr. Shadbolt, which certainly possesses great advantages, is very ably followed up by Mr. Mansell, of Guernsey, who published a modification or improvement on Mr. Shadbolt's process. It is nearly as follows:—

After paying some merited compliments to Mr. Shadbolt for his valuable invention, Mr. Mansell adds—"The plate having been carefully cleaned and iodized as usual, the subsequent manipulation resolves itself into three heads.

"First. To reduce the amount of free nitrate of silver on the plate to nearly the minimum necessary for its sensitiveness in the camera.

"Having drained the plate, immerse it in a vertical bath of distilled water for one or two minutes; take it out, and drain it by resting one edge on blotting-paper. Another method is to pour on the plate, very gently, and not on one spot, as much distilled water as it will carry, leaving it on for two minutes. I prefer the washing-bath; but the second method may be useful on occasion.

"*Remarks.*—The addition of nitrate of silver to the washing-bath is superfluous; the capillarity of the villous surface of the iodized film retains as much as is necessary. The bath of course soon acquires nitrate of silver from the plates; but this is no injury till it becomes excessive. When the amount exceeds one grain per ounce, the bath must be diluted.

"Second. To preserve the surface of the plate moist, and the free nitrate of silver on it from crystallizing, by means of a hygrometric coating of syrup.

"Give the washed plate two doses of syrup, leaving each on for about two minutes, with waving. I use syrup which has done duty as the second dose of one plate, for the first dose of the next plate, always finishing with fresh syrup. Oscilate the plate from angle to angle, resting on blotting-paper, to obtain a perfectly mirrored surface, and store away for use. The plates will keep for a month or six weeks.

"*Remarks.*—The syrup is made by taking, half and half, pure honey and distilled water, and filtering; in fact, it ought to be as dense as can pass through ordinary white filtering-paper. The greatest care should be taken to avoid the reduction of any portion of the free nitrate of silver in long-kept plates, by having the hygrometric film as free from it as possible.

"Third. To remove the syrup perfectly from the plate before developing.

"On this the perfection of the result mainly depends. The syrup, after it has been on the plate a short time, consists of two layers; an outer one, which remains soft and hygrometric for a long time, and is soluble in cold water, and an inner film, a compound of syrup and nitrate of silver, which is insoluble in cold water. This is easily proved by washing the plate in a vertical glass bath, where this layer is seen separating in bran-like scales, the water mechanically removing it. These scales may also be collected on a filter and examined. This inner layer (with a mean temperature of 46° Fah., and a mean degree of humidity of ·836), after about 150 hours, becomes adherent to the collodion—at first round the margins of the plate, and then to the whole surface, covering it as with a varnish, which no amount of washing in cold water will remove. This indurated syrup is soluble in hot water; but it is far more effectually and safely got rid of by steaming. On removing the plate from the dark slide, immerse it in the washing-bath for five minutes, to remove the outer syrup; drain it, then hold it, collodion downwards, over the steam of boiling water, poured in a pan, for about ten minutes (the water is to be renewed if the steam does not rise freely), taking care to keep the plate four or five inches from the surface of the water; the indurated syrup will be seen gradually to dissolve, and, by inclining the plate, may be run off at any angle you choose. In the process of steaming, if any part of the surface is disposed to dry, as will sometimes be the case, where the coating of syrup happens to be thinner than elsewhere, it must be kept wet by causing the fluid on the

plate to run over it. Allow the plate to drain, then remove the remaining syrup by gently pouring distilled water over it once or twice. Drain the plate, and pour on pyrogallic acid (no image whatever appears under this); after a minute or two, when the iodized film has been well impregnated, pour off the pyro into a glass containing about an eighth of its volume of a thirty-grain nitrate of silver solution, and immediately pour it over the plate. The image rapidly comes out, and may be developed as usual to any extent.

"*Remarks.*—The first washing-off of the outer layer of syrup may be effected by pouring one or two waters on the plate, leaving them on for a few minutes. I prefer the washing-bath, and only mention this as a makeshift for travellers, who may thus avoid the necessity of carrying one. The development is so even, that on a 9 × 7 plate it is almost impossible to say where it commences; the uniform anastasis of the picture is one of the most beautiful experiments that can be witnessed—it rises up like an exhalation, and its perfection is exquisite. The negative high lights are as transparent as glass, and the half-tones and blacks all that can be desired. The steamed and washed plate, before development, consists of a film of iodide of silver, nearly pure, in a state of actinic tension, the free nitrate of silver having been almost entirely removed; indeed, by repeating the steaming and washing, this can be done so perfectly that the plate may be exposed to diffused daylight without injury. This is a remarkable experiment, which throws so much light on the theory of this truly wonderful art, that it will amply repay any one who has leisure and talent to follow it up. The negatives obtained from plates that have thus been deprived of their original free nitrate of silver, are equal in every respect to others that have not been so treated. Among other advantages, steaming the plates cleanses them so perfectly, and gives us such complete mastery over this method, that I now always use it, whether kept a long or a short time; the trouble is nothing, the result certain."

Mr. Mayall's Dry Collodion Process.—As the subject of preserving collodion plates for a long time without destroying their sensitiveness is one of vital importance, I cannot refrain from giving Mr. Mayall's process for using a dry collodion; and I may add that the same gentleman, at a considerable sacrifice of time and money, gave one of the most instructive lectures on the albuminized process on glass ever brought before the London Photographic Society. I have already given the substance of this lecture, and shall now give his method for using dry collodion, as copied from the pages of the London Photographic Journal:—

"The object of this paper," he says, "is to explain a process by which collodion can be used dry. It may be well, before describing the mere process, if we endeavour to comprehend somewhat of the chemical action which is necessary to the production of a good collodion, and to explain the law of substitution, upon which the reactions of this highly complex organic compound may be said to depend.

"It is well known to chemists that there are a number of organic substances, which, when treated with chlorine gas, take up a number of measures of that gas, equal to the number of measures of hydrogen that are taken from it by another portion of the chlorine. Gay Lussac was the first to observe this phenomenon, and Dumas afterwards remarked the same change in oil of turpentine, and founded upon it his 'theory of substitution.'

"Example:—Acetic acid, $C_4H_4O_4$, is converted by the action of chlorine into chloracetic acid, $C_4\ HCl_3\ O_4$, without altering the form or appearance of the original acid.

"This latter product forms with oxide of silver a soluble salt, without any precipitation of chloride of silver; whereas chlorine, in all the inorganic compounds of which it forms the electro-negative element, yields with silver solutions a precipitate of chloride of silver.

"Again, ether may be taken as oxide of ethyl, C_4H_5O, ethylene being the primary nucleus, $C_4H_4 + HO$; by the successive action of chlorine it may be converted as follows:—

Oxide of ethyl	$C_4 H_5 O$
By action of chlorine becomes . .	$C_4 H_4 Cl O$
	$C_4 H_3 Cl_2 O$
	$C_4 Cl_5 O$

"It will be observed that the chlorine displaces an atom of hydrogen, and this action continues until hydrogen vanishes from the series.

"Now, although chlorine was the first electro-negative element that was observed to have this property of substitution, more recent investigation has shown that iodine, bromine, and even fluorine and some of the metals, have the property also, and form with ether:—

Oxide of ethyl	$C_4 H_5 O$
Iodide of ethyl	$C_4 H_5 I$
Bromide of ethyl	$C_4 H_5 Br$.
Chloride of ethyl	$C_4 H_5 Cl$.
Zincethyl	$C_4 H_5 Zn$.

And the metal ethyls again form iodides, bromides, &c.

"Now these ethyls on a first glance should be analogous to the true iodides, chlorides, bromides, and should immediately yield precipitates with the usual tests employed for their detection; but they do no such thing; they are completely masked, and do not exhibit any of their usual characteristics. If, with Berzelius, in his *Binary Theory*, we regard them as compounds of chlorine, iodine, and the radical ethyl $C^4 H_5$, they do not precipitate silver solutions. The chlorine, iodine, bromine, exist in their constitution in a totally different manner.

Similarly, marsh gas	$C_2 H_4$
produces Chloroform	$C_2 H Cl_3$
Bromoform	$C_2 H Br_3$
Iodoform	$C_2 H I_3$

"Laurent and Gerhardt, in the French school, have greatly expanded this subject, and, in the opinion of chemists, have even gone too far to accord with well-established views in chemistry. Much remains for the experimentalist before the true limits of substitution can be properly defined.

"One thing, however, is established without fear of controversy; that is, that oxide of ethyl when brought into contact with chlorine, first loses its hydrogen, and is transformed into a chlorethyl, and eventually every atom of its hydrogen is abstracted.

"Iodine produces a similar effect, until at last the iodide of ethyl has completely replaced the original ether, and has produced that decomposition which it is the province of the light to effect. Hence a collodion that has undergone this change is no longer, or only feebly, sensitive to the electro-negative ray of light, and this will account for the deterioration of excited collodion.

"Now, as every excited collodion becomes deteriorated by keeping, the question

has strongly impressed me—Is it possible to impregnate the ether with any substance rich in hydrogen that would repair the waste going on in the excited collodion? And, after trying various substances, I have found four that do actually repair, or rather that give off their hydrogen first, and so keep the ether intact. These are—

Benzine . . .	$C_{14} H_5 O_2$
Naphthaline . .	$C_{20} H_8$
Hellenin . . .	$C_{15} H_8$
Terpenole . .	$C_{28} H_{17} O$

"Very small quantities of these substances added to the ether prevent it running into iodides, bromides, and chlorides of the ethyls, still leaving in the collodion sufficient of electro-positive elements to enable the light to push the iodide of silver out of its feeble combination.

"What Liebig calls the eremecausis of organic bodies—that is, the slow decomposition by the absorption of oxygen—is one of the leading characteristics of highly complex organic forms rich in hydrogen, analogous to putrefaction of nitrogenized substances. In the instances above quoted there are two affinities in action:—first, the affinity of nitrogen for hydrogen, and of carbon for oxygen, and both facilitate the disruption of the elements of the complex organic form; decay and utter annihilation of organism takes place; the elements are again restored to the inorganic world. Those who wish to pursue the inquiry as a purely chemical investigation, I refer to Liebig's 'Vegetable Physiology.'

"The chemistry of this process is somewhat obscure. However, some of our ablest photographic chemists are now investigating it, and no doubt from their labours much may be expected.

"The usual plain collodion is excited with—

"No. 1.—3 grains of iodide of cadmium.
1 grain of chloride of zinc.
1 ounce of collodion.
½ ounce of alcohol.

"Dissolve the chemicals in the alcohol, and then mix with the collodion.

Or, No. 2.—3 grains of iodide of zinc.
1 grain bromide of cadmium.
Or, No. 3.—2 grains iodide of cadmium.
1 grain bromide of cadmium.
$\frac{1}{60}$ grain bromide of iron.
$\frac{1}{10}$ grain bromide of calcium.

"In the last it will be necessary to dissolve one grain of bromide of iron in one drachm of alcohol, and use one fluid grain of the solution. Similarly three grains of bromide of calcium must be dissolved in one drachm of alcohol, and one fluid grain used.

"The excited collodion will require to stand a few days to settle completely. Decant into a dry bottle, to avoid sediment. Spread as usual.

"*Bath*—which for distinction sake we will call albuminate of silver:—

16 ounces distilled water.
1 ounce albumen.
1½ ounce nitrate of silver (neutral).
1½ ounce glacial acetic acid.
2 grains iodide of potassium.

"The albumen and water must be well mixed first, then the glacial acetic acid added; shake up, and let stand three hours; then the nitrate of silver in crystals, shake and filter, stand twenty-four hours; then add the iodide of potassium, filter again, ready for use. Coat the plate, as usual, with collodion, and use the albuminate of silver bath as an ordinary silver bath; wash in another bath of distilled water five minutes, then wash the back of the plate with common water, the front with distilled; set the plate aside to dry in a vertical position, in a place free from dust. It will keep three weeks. Expose in the camera as usual, from two minutes to ten, according to the light, diaphragm, &c. Pass into the silvering bath again three minutes. Develop with—

6 to 8 grains protosulphate of iron.
1 ounce distilled water.
1 drachm glacial acetic acid.

Wash, and fix with—

1 cyanide of potassium.
20 water.

"It is about as quick as albumen in the camera. The albuminate of silver bath must on no account be exposed to daylight, nor the developing solution. Potassium and ammonium salts will do to excite the collodion; but it will not keep so long as with the metallic iodides.

Tests of the Strength of Acids.—One of the great causes of failure, to which the best photographers are liable, is to be found in the adulteration and impurity of the chemicals used. To this question Mr. Hardwich directed much of his attention, and the following are some of the tests and remedies his experiments suggested to him:—

"*Nitro-Sulphuric Acid.*—Plan for making nitro-sulphuric acid, the specific gravity of the two acids not having been previously determined:—Take a strong sample of nitric acid (the yellow nitrous acid, so called, succeeds very well), and mix it with oil of vitriol as follows:—

Sulphuric acid	10 fluid drachms.
Nitric acid	10 ,,

"Now immerse a thermometer, an indispensable article, and note the temperature. If the oil of vitriol is good, it should be about 130°. If it sinks below 120°, place the mixture in a capsule (a teacup will answer the purpose), and float upon boiling water for a few minutes.

"Having done this, a preliminary experiment with a small tuft of cotton wool will speedily indicate the actual strength of the nitro-sulphuric acid. Stir the tuft in the mixture for five minutes. Remove it with a glass rod, and wash with water for ten minutes until no acid taste can be perceived. If the wool becomes matted, and gelatinizes slightly on its first immersion in the acid; or if, in the subsequent washing, the fibres appear to adhere and to be disintegrated by the action of the water, the nitro-sulphuric acid is too weak. In that case, add to the acid mixture oil of vitriol three

drachms. If the cotton was actually dissolved in the first trial, an addition of half a fluid ounce of oil of vitriol may be required.

"Supposing the cotton not to be gelatinized and to wash well, then wring it out very dry, pull out the fibres, and treat it in a test-tube with rectified ether, to which a few drops of alcohol have been added, If it is insoluble, dry it by a gentle heat and apply a flame. A brisk explosion indicates that the nitro-sulphuric acid employed is too strong. In that case, add to the twenty drachms of mixed acids, water one drachm, or even one drachm and a half, if the compound was very highly explosive.

"There is a third condition, somewhat different from either of the above, which is puzzling to a beginner. It is this:—The fibres of the cotton mat together very slightly or not at all on immersion, and the washing proceeds tolerably well; the compound formed is scarcely explosive, and dissolves imperfectly in ether, leaving little nodules or hard lumps of unaltered cotton. The ethereal solution yields, on evaporation, a film which is opaque instead of transparent. In this case, the acid mixture is slightly too weak, or the temperature is too low, being probably about 90° instead of 120° to 130°. When the acid mixture has been brought to the proper strength by a few preliminary trials, proceed according to the directions given a few pages in advance.

"*Preparation of Nitro-sulphuric Acid.*—The process by oil of vitriol and nitre is recommended, in preference to the other, to the amateur who is unable to obtain nitric acid of convenient strength. The common oil of vitriol sold in the shops is often very good for photographic purposes; nevertheless it is best, if possible, to take the specific gravity. At a temperature of 58° to 60°, specific gravity 1·833 is about the usual strength, and if it falls below this, it will be better to reject it.

"The nitre should be the purest sample which can be obtained. Commercial nitre often contains a large quantity of chloride of potassium; detected on dissolving the nitre in distilled water, and adding a drop or two of solution of nitrate of silver. If a milkiness and subsequent curdy deposit is formed, chlorides are present.

"These chlorides are injurious; after the oil of vitriol is added, they destroy a portion of nitric acid by converting it into brown fumes of peroxide of nitrogen, which alters the strength of the solution.

"Therefore, if pure nitrate of potash, free from chlorides, can be obtained, the slight additional expense is not worth being taken into account; but if not, the finest crystals of commercial nitrate may be picked out, and will probably answer the purpose.

"Nitrate of potash is an anhydrous salt—it contains simply nitric acid and potash, without any water of crystallization; still, in many cases, a little water is retained mechanically between the interstices of the crystals, and therefore it is always better to dry it before use. This may be done by laying it in a state of fine powder upon blotting-paper, close to a fire, or upon a heated metallic plate.

"Whether previously dried or not, the sample must be reduced to a fine powder before adding the oil of vitriol; otherwise portions of the salt escape decomposition.

"Supposing these preliminaries to have been properly observed, weigh out pure nitre, powdered and dried, 600 grains. This quantity is equivalent to one and a quarter ounce troy or apothecaries' weight, and to one and a quarter ounce avoirdupois weight + 54 grains. Place this in a tea-cup or any other convenient vessel, and pour upon it water one fluid drachm and a half mixed, with oil of vitriol twelve fluid drachms. Stir well with a glass rod for two or three minutes, until all effervescence has ceased, and an even pasty mixture, free from lumps, is obtained.

"During the whole process, abundance of dense fumes of nitric acid will be given off, which must be allowed to escape up the flue or into the open air.

"The above formula will invariably succeed with a good sample of oil of vitriol and pure nitre. When tried, however, with commercial nitre, it failed in the writer's hands, the cotton being gelatinized and dissolved. Therefore, in a second experiment, the addition of water was omitted, and the result proved satisfactory."

Mr. Hadow recommends the following for employment with commercial nitre :—

Nitre, powdered and dried . .	510 grains.
Oil of vitriol	15½ drachms.
Water	1½ drachm.

"Observe that the quantity of oil of vitriol in this formula is increased, to allow of the water being retained. The resulting mixture is very fluid and transparent, and the manipulation easy. The writer has seen this formula tried twice, with samples of common nitre purchased at an oil-shop. In the first the product was highly satisfactory, but in the second not quite so good, being only partially soluble and giving an opalescent film. In this case, probably, a better result would have been obtained by halving the quantity of water directed.

"*Washing and Drying the Pyroxyline.*—The mixture of sulphuric acid and nitre requires to be used immediately after its preparation, as it solidifies into a stiff mass on cooling; but the mixed acids may be kept for any length of time in a stoppered bottle.

"The fibres of the cotton should be well pulled out, and small tufts introduced singly, stirring with a glass rod in order to keep up a constant interchange of particles of acid. The paper is cut into small squares or strips, and treated in the same way.

"The quantity of either must not be too great, or some portions will be imperfectly acted upon; about twenty grains to each fluid ounce of the mixture will be sufficient.

"Time of immersion varies from ten minutes with cotton to twenty minutes, or even half an hour, with the paper. When an unusually large proportion of sulphuric acid is used, as in the formula given for the commercial nitre, the cotton should be removed at the expiration of six or seven minutes, as there is a tendency to partial solution of the pyroxyline in the acid mixture under those circumstances.

"After the action is complete, the nitro-sulphuric acid is left weaker than before, from addition of various atoms of water necessarily formed during the change. Hence, if the same portion be used more than once, an addition of sulphuric acid will be required.

"In removing the pyroxyline from the nitro-sulphuric acid, press out as much of the liquid as possible, and wash it rapidly in a large quantity of cold water, using a glass rod in order to preserve the fingers from injury. If it were simply thrown into a small quantity of water and allowed to remain, the rise in temperature and weakening of the acid mixture might do mischief.

"The washing should be continued for at least a quarter of an hour, or longer in the case of paper, as it is most essential to get rid of every trace of the acid. When the nitre plan has been adopted, a portion of the bisulphate of potash formed adheres very tightly to the fibres, and if not carefully washed out, an opalescent appearance is seen in the collodion, resulting from the insolubility of this salt in the ethereal mixture.

"If no acid taste can be perceived, and a piece of blue litmus-paper remains in

contact with the fibres for five minutes without changing in colour, the product is thoroughly washed. Nevertheless, if time can be spared, it is a safe plan to place the pyroxyline in warm water, and allow it to soak for several hours.

"Lastly, wring it out in a cloth, pull out the fibres, and dry by a gentle heat, always bearing in mind that the compound is more or less explosive, and therefore must not be brought too near to the fire. After drying, it may be kept for any length of time in a stoppered bottle. It has been stated, on good authority, that pyroxyline is in some cases liable to a spontaneous decomposition, attended with evolution of red fumes of peroxide of nitrogen. This, however, must be rare, as the writer has not often met with it in the course of his experience.

"RECAPITULATION.—*The Acid Mixture too strong.*—The appearance of the cotton is not much altered on its first immersion in the mixture. It washes well, without any disintegration. On drying, it is found to be strong in texture, and produces a peculiar crackling sensation between the fingers, like starch. It explodes on the application of flame, without leaving any ash; it is insoluble in the mixture of ether and alcohol, but dissolves if treated with acetic ether.

"*The Acid Mixture of the proper strength.*—No agglutination of the fibres of the cotton on immersion, and the product washes well; soluble in the ethereal mixture, and yields a transparent film on evaporation.

"*The Acid Mixture too weak.*—The fibres of the cotton agglutinate, and the pyroxyline is washed with difficulty. On drying, the texture is found to be short and rotten. It does not explode on being heated, but either burns quietly with a flame, leaving behind a black ash (in which case, probably, it consists simply of unaltered cotton), or is only slightly combustible, and certainly not explosive. Treated with the ethereal mixture, it dissolves only partially, leaving behind lumps of unchanged cotton. The solution does not form an even transparent layer on evaporation, but becomes opaque and cloudy as it dries. This opacity, however, may be seen to a small extent with any sample of pyroxyline, if the solvents contain too much water.

"By studying these characters, and at the same time bearing in mind that a drachm and a half of water in the quantities of acid given for the formulæ will suffice to cause the difference, it is hoped that the operator will overcome all difficulties.

"*Purification of Collodion Solvents.*—The purity of the ether employed is a matter of more importance in the manufacture of a good collodion than that of any other ingredient. This point must be attended to in order to secure a good result.

"There are three kinds of ether sold by manufacturing chemists:—First, ordinary rectified sulphuric ether, as it comes from the distilleries, containing a certain per centage of alcohol, and also of water; if it is good, the specific gravity is about ·750. Second, the washed ether, which is the same agitated with an equal bulk of water, in order to remove alcohol. By this proceeding the specific gravity of the fluid is reduced considerably. Third, ether both washed and re-rectified, so as to contain neither alcohol nor water; in this case the specific gravity should not be higher than ·720.

"The first of these commercial varieties is the one usually employed by photographers, since it is sold at a lower price than the others; sometimes it is exceedingly pure and good, and is then to be preferred to the washed ether; but often this is not the case.

"Some of the qualities which render ether unfit for photographic purposes, are as follows:—A peculiar and disagreeable smell, either of some essential oil or of acetic ether; an acid reaction to test-paper; a property of turning alcoholic solution of

iodide of potassium brown with unusual rapidity; a high specific gravity, from superabundance of alcohol and water.

"The ether which has been both washed and redistilled is always the most uniform in composition, and especially so if the second distillation was conducted from quicklime, carbonate of potash, or caustic potash. These alkaline substances certainly retain the impurities, which appear to be of an acid nature, and leave the ether in the best possible state for use.

"The redistillation of ether is a simple process, and therefore it will be decribed. In dealing with ether, however, in any form, the greatest caution must be exercised, on account of its inflammable nature. Even in pouring ether from one bottle into another, if a light of any kind be near, the vapour is apt to take fire; and severe injuries have been occasioned from this cause.

"*Purification of Ether.*—Take ordinary rectified sulphuric ether, and agitate it well with an equal bulk of water, in order to wash out the alcohol; stand it for a few minutes until the contents of the bottle separate into two distinct strata, the lower of which—*i.e.*, the watery stratum—is to be drawn off and rejected. Then introduce caustic potash finely powdered, in the proportion of about one ounce to a pint of the washed ether; shake the bottle again many times, in order that the water—a small portion of which is still present in solution in the ether—may be thoroughly absorbed. Afterwards set aside for twenty-four hours (not longer), at the end of which time it will probably be observed that the liquid has changed to a straw-yellow colour, and that a flocculent deposit has formed in small quantity. Lastly, transfer to a retort of moderate capacity, supported in a saucepan of warm water, and properly connected with a condenser. On applying a gentle heat, the ether distils over quietly, and condenses with very little loss; care must of course be taken that none of the alkaline liquid contained in the body of the retort finds its way, by projection or otherwise, into the neck, so as to run down and contaminate the distilled fluid.

"A more economical plan of purifying ether is, without previous washing with water, to agitate with carbonate of potash or with quicklime, and redistill at a low temperature.

"In order to preserve ether from decomposition, it must be kept in stoppered bottles, quite full, and put away in a dark place; also the stoppers should be tied over with a bladder, or a considerable amount of evaporation will take place, unless the neck of the bottle has been ground with unusual care. After the lapse of some months, probably a certain amount of decomposition—evidenced by the liberation of iodine from iodine of potassium—will be found to have taken place, in spite of all precautions. This, however, is small in amount and not of a character to injure the fluid, except when very transparent films are employed, in which the amount of iodide of silver is reduced to a minimum.

"*Purification of Spirits of Wine.*—The object of this operation is to remove a portion of water from the spirit, and so to increase its strength. Alcohol thus purified may be added to collodion almost to any extent, without producing glutinosity and rottenness of film.

"The salt termed carbonate of potash is a 'deliquescent' salt—that is, it has a great attraction for water; consequently, when spirits of wine are agitated with carbonate of potash, a portion of water is removed, the salt dissolving in it and forming a dense liquid which refuses to mix with the alcohol, and sinks to the bottom. At the expiration of two or three days, if the bottle has been shaken frequently, the action

is complete, and the lower stratum of fluid may be drawn off and rejected. Pure carbonate of potash is an expensive salt, and therefore a commoner variety may be taken. Even pearlash—a highly impure form of carbonate—will succeed, if no better is at hand.

"The quantity of carbonate of potash used may be about an ounce and a half to half a pint of spirit; an excess, however, does no harm.

"After the distillation is complete, a fluid is obtained containing about 90 per cent. of absolute alcohol, the remaining 10 per cent. being water. The specific gravity at 60° Fahrenheit should be about ·823; commercial spirit of wine being ·836 to ·840.

"*Preparation of the Iodizing Compounds.*—These are the iodides of potassium, ammonium, and iron, also the double iodide of potassium and silver.

"*The Iodide of Potassium.*—Iodide of potassium, as sold in the shops, is often contaminated with various impurities. The first and most remarkable is carbonate of potash. When a sample of iodide of potassium contains much carbonate of potash, it forms small and imperfect crystals, which are strongly alkaline to test-paper, and become moist on exposure to the air, from the deliquescent nature of the alkaline carbonate. Sulphate of potash is also a common impurity; it may be detected by chloride of barium. Commercial iodide of potassium, however, is rarely so pure that no change whatever is produced by chloride of barium; therefore a mere opalescence or slight milkiness on adding the test solution may be disregarded; but if a decided white precipitate is formed, it will be better to reject the sample, or to purify it by solution in strong alcohol.

"A third impurity of iodide of potassium is chloride of potassium; it is detected as follows:—Precipitate the salt by an equal weight of nitrate of silver, and treat the yellow mass with solution of ammonia; if any chloride of silver is present, it dissolves in the ammonia, and after filtration is re-precipitated in white curds by the addition of an excess of pure nitric acid. If the nitric acid employed is not pure, but contains traces of free chlorine, the iodide of silver must be well washed with distilled water before treating it with ammonia, or the excess of free nitrate of silver dissolving in the ammonia would, on neutralizing, produce chloride of silver, and so cause an error.

"Iodide of potassium may be rendered very pure by re-crystallizing from spirit, or by dissolving in strong alcohol of specific gravity ·823, in which both sulphate and carbonate of potash are insoluble. The proportion of iodide of potassium contained in saturated alcoholic solutions varies with the strength of the spirit.

"*The Iodide of Ammonium.*—This salt may be prepared by adding carbonate of ammonia to iodide of iron, but more easily by the following process:—A strong solution of hydrosulphate of ammonia is first made, by passing sulphuretted hydrogen gas into liquor ammonia. To this liquid iodine is added until the whole of the sulphuret of ammonium has been converted into iodide. When this point is reached, the solution at once colours brown from solution of free iodine. On the first addition of the iodine, an escape of sulphuretted hydrogen gas and a dense deposit of sulphur take place. After the decomposition of the hydrosulphate of ammonia is complete, a portion of hydriodic acid—formed by the mutual reaction of sulphuretted hydrogen and iodine—attacks any carbonate of ammonia which may be present, and causes an effervescence. The effervescence being over, the liquid is still acid to test-paper, from excess of hydriodic acid; it is to be cautiously neutralized with ammonia, and evaporated by the heat of a water-bath to the crystallizing point.

"The crystals should be thoroughly dried over a dish of sulphuric acid, and then sealed in small tubes containing each about half a drachm of the salt.

"The writer invariably employs the iodide of ammonium for the purpose of iodizing collodion, and finds that at the expiration of two years from the time of preparation the salt is still perfectly colourless.

"Iodide of ammonium is very soluble in alcohol; but it is not advisable to keep it in solution, from the rapidity with which it decomposes and becomes brown.

"The most common impurity of commercial iodide of ammonium is sulphate of ammonia; it is detected by its sparing solubility in alcohol.

"*The Iodide of Iron.*—Iodide of iron, in a state fit for photographic use, is very easily obtained by dissolving about a drachm of iodine in an ounce of 'proof spirit'—that is, a mixture of equal bulks of spirits of wine and water, and adding an excess of iron filings. After a few hours, a green solution is obtained without the aid of heat. The presence of metallic iron in excess prevents the liberation of iodine and deposit of peroxide of iron, which would otherwise speedily occur.

"*Double Iodide of Potassium and Silver.*—In preparing this compound, first form iodide of silver by dissolving equal weights of iodide of potassium and of nitrate of silver in separate portions of rain or distilled water, and washing the resulting yellow precipitate upon a filter. The washing is to be conducted, first, with water to wash away the nitrate of soda, and afterwards with a small portion of alcohol to displace the water.

"Then digest the yellow mass with excess of iodide of potassium in spirits of wine, until a saturated solution of the double salt is obtained.

"An analysis of a saturated solution of double iodide of potassium and silver in alcohol of specific gravity ·836, gave, as the quantity of both salts present in one fluid ounce, iodide of potassium, sixty-four grains; iodide of silver, twenty-four grains. Therefore in the preparation one and a-half drachm of powdered iodide of potassium, and about twenty grains of iodide of silver, obtained by precipitating fifteen grains of nitrate of silver by an equal weight of iodide of potassium, may be digested for some hours in an ounce of the spirits of wine.

"*Iodide of Cadmium.*—This salt is formed by heating filings of metallic cadmium with iodine, or by mixing the two together with addition of water.

"Iodide of cadmium is very soluble both in alcohol and water; the solution yielding on evaporation large six-sided tables of a pearly lustre, which are permanent in the air. The crystalline form of this salt is a sufficient criterion of its purity."

The Collodio-Albumen Process.—Another process for facilitating the use of the collodion, has been brought forward by Mr. Ackland, a gentleman connected with Messrs. Horne and Thornthwaite's establishment, which, with their permission, we are enabled to give:—

"This is a process, invented by Dr. Taupenot, for obtaining negatives on glass, which bids fair to outrival all others, being easy of manipulation, and giving results of the most exquisite minutiæ and beauty. Glass plates, when prepared and excited by this process, may be kept at least a fortnight before being developed, and these plates when exposed in the frame may be developed immediately, or kept for days before commencing this operation. Indeed it is quite possible to prepare and excite a number of plates before leaving home to go on a tour of twelve or fourteen days; to expose the plates at any time or place during the journey, and bring them home to be developed.

"The manipulation may be said to consist of nine distinct operations:—

"1. *Cleaning the Plate.*—For which the directions already given will suffice.

"2. *Coating with Iodized Collodion.*—The collodion necessary to be used in this process must be one yielding good *negative* pictures—that supplied by Horne and Thornthwaite, under the name of negative collodion, answers admirably. This is supplied either ready iodized, or the collodion and iodizing in separate bottles. As this collodion becomes less sensitive, after being iodized a fortnight, it is advisable to iodize no more than will be used in that time—therefore, obtain the collodion and the iodizing solution separate, as the mode of iodizing this collodion is very simple. Half an ounce of the iodizing solution is mixed with one ounce and a half of collodion, and the mixture allowed to settle twelve hours before being used; and it is even advisable to pour off the clear solution into a perfectly clean bottle, in order to get rid of any insoluble matter which may fall to the bottom. The plate having been thoroughly cleaned, and received its final polish by the use of a prepared chamois leather, is coated with the negative collodion, which has been iodized at least twelve hours, and allowed to settle.

"3. *Exciting the Collodion Film.*—After the ether has evaporated, and the surface of the collodion appears set, the plate must be laid, collodion side upwards, on a glass dipper, and plunged, with *one downward movement*, into a bath filled to within an inch of the top with collodion bath solution, prepared by dissolving one ounce of nitrate of silver in two ounces of distilled water, and two grains of iodide of potassium in one drachm of distilled water; mix the two solutions and shake well together, until the precipitate which is first thrown down is redissolved; when this takes place, add fourteen ounces of distilled water, and two drachms of alcohol. On the addition of the water, a turbidness ensues, which must be removed by the solution being very carefully filtered through filtering-paper; and the filtered liquid should be clear and transparent, free from any deposit or floating particles, and must possess a slightly acid reaction of test-paper.

"In order to ascertain if the solution thus prepared possesses the necessary amount of free acid without superabundance, proceed to test and to correct it, if necessary. The solution must be carefully filtered through filtering-paper before being used. After the plate has been allowed to remain in the bath one minute, it is lifted out three or four times, in order to facilitate the removal of the *oily appearance* which the plate now presents. When the surface appears wetted uniformly, on being drawn out of the solution the plate is removed from the dipper, and the excess of solution drained off, and is then placed, collodion side upwards, on a fixing stand, and distilled or filtered rain water poured over the surface, so as to remove *as much as possible of the bath solution* from the surface. The plate is now removed from the fixing stand, the back well washed with water, and then placed nearly upright on blotting-paper, with the face against a wall for *one minute*, to drain. This and subsequent operations (except exposure in the camera) must be performed in a dark room.

"4. *Coating with Albumen.*—Having allowed the plate to drain one minute, place it again on a levelling stand, with the film upwards, and pour over it as much of the iodized albumen as the plate will hold, from a glass measure containing not more than enough of the albumen to coat two plates, pour off the excess into the measure and again cover the plate with albumen three separate times; ultimately, drain off as much as possible of the excess of albumen, and place the plate nearly upright against the wall, with the coated side inwards, to dry, which takes place in an ordinary temperature in about one hour.

"In coating with albumen, the presence of air-bubbles or dust must be guarded against. The former can easily be done by taking care, in pouring the albumen into the measure and on the plate, not to pour so as to generate air-bubbles in the liquid. But should any be detected, hold the plate horizontally and give it another coating of albumen; then incline the plate so that the bulk of the liquid shall pass over and carry off the bubbles with the running stream. Dust on the plate must be prevented by operating in a room as free from this photographic enemy as possible.

"In order to render the coating of albumen as uniform as possible, the plate must stand to dry on two or three layers of filtering-paper, and the upper surface must touch the wall at *one point only*, and not be allowed to rest against it along its entire upper edge.

"When the albumen coating is *thoroughly dry* (and not till then), the plate is ready to be excited; but if more have been prepared than are likely to be used for taking pictures on during the next ten days or fortnight, they may be stowed away in a plate box, ready to receive the sensitive coating at any time. The author's experience has led him to believe that these albuminized plates will keep good any length of time, as plates which had been coated a month, when excited, exposed, and developed, appeared to possess all the properties of recently prepared plates.

"*5. Exciting the Albumen Coating.*—Prior to the plates being excited they must be *thoroughly dry* and free from any particles of loose dust on the surface, back, or edge. Sufficient of the albumen bath solution must be filtered through filtering paper to fill a dipping bath of the required size, so that the plate can be immersed in it.

"The careful filtering of the fluid is very necessary in order to free it from any floating particles, and to separate the animal charcoal.

"A bath having been prepared by dissolving an ounce and a half of nitrate of silver in sixteen ounces of distilled water; adding one ounce of glacial acetic acid, with two drachms animal charcoal, which has been kept for use in a closely stoppered bottle—the plate is now taken and laid, albumen side upwards, on the dipper, and then lowered into a bath with *one steady downward movement*, where it is allowed to remain *one minute;* it is then taken out, the excess of liquid drained off, and placed on the fixing stand, with the albumen surface uppermost, and a stream of water poured over it for at least one minute, so as to remove every particle of the bath solution. This complete washing is very necessary, in order to prevent stains in the after development, which invariably takes place around the edges, if not thoroughly washed. The plate, having been thoroughly washed, is leaned against a wall to dry, or, if required for immediate exposure, may be dried on a plate of heated metal or foot-warmer; but in no case must the exposure in the camera take place until the surface is thoroughly dry.

"*6. Exposure in the Camera.**—As before stated, this operation may take place immediately the plate is thoroughly dry after being excited, or a fortnight may intervene between the exciting and exposure, provided the plate is kept very carefully excluded from light and any chemical or sulphurous vapours, in a plate box adapted for that purpose, with the sensitive surface towards the back of the box. When the exposure is about to take place, or at any time previously, the camera backs may each have a plate placed in them ready for exposure; to do this, the camera back must be taken into the operating room and the door closed, so as to exclude all white

* Care must be taken that the direct rays from the sun shall not fall on the lens or enter the camera during the exposure of a plate.

light. The hinged flap of the camera back is opened, and the prepared plate laid, with its sensitive surface *downwards*, or next the sliding flap, so that its corners may rest on the silver wire corners of the plate frame previously placed within the camera back ready to receive it. The hinged flap is now closed and kept from opening by turning the flap button over it; the sliding flap is examined to see that it is pushed closely down so as to guard any access of light, and it is then ready to be placed in the camera, and may be taken into the open air with impunity. Should the exposure not take place immediately, or should the camera back have to be carried any distance, it is advisable either to wrap it up in a black cloth, or secure the flaps from the chance of coming open, during transit, by stout string being tied around the back.

"The focusing is conducted in the same way as usual, and the cap replaced on the lens; the focusing glass is now removed, and the camera back fitted into the same aperture, *with the sliding flap next the lens*. The sliding flap is pulled up to its fullest extent, placing the hand on the camera back to prevent it rising out of the camera with this action. The cap of the lens is then removed, so that the light may be admitted into the camera, and to fall on the sensitive surface of the plate. After the necessary time of exposure has taken place, the cap is replaced on the lens, the sliding flap is pushed down, and the camera back withdrawn from the camera; the plate can then be taken into the operating room to be developed, or this operation may be deferred for days, or even a week or more if convenient. The time of exposure in the camera varies according to the intensity of the light and the aperture and focal length of the lens; therefore, to give the exact time of exposure would be impossible, still it may assist the amateur if I give the time required in summer with full sunshine, and merely state that this time may be increased to double in winter or dull weather.

"In the ordinary sunshine of a summer's day the time of exposure will be—

"30 seconds with a lens of 4-inch focus and $\frac{1}{2}$-inch stop.

"21 seconds with a lens of 4-inch focus and $\frac{3}{4}$-inch stop.

" 5 seconds with a lens or 4-inch focus and $1\frac{1}{4}$-inch aperture, with no stop.

" $1\frac{1}{2}$ minute with a lens of 6-inch focus and $\frac{1}{4}$-inch stop.

" $4\frac{1}{2}$ seconds with a lens of 6-inch focus and $2\frac{1}{4}$-inch aperture, with no stop.

" 2 minutes with a lens of 8-inch focus and $\frac{1}{4}$-inch stop.

" $1\frac{1}{2}$ minute with a lens of 8-inch focus and $\frac{1}{2}$-inch stop.

" $3\frac{1}{2}$ minutes with a lens of 10-inch focus and $\frac{1}{2}$-inch stop.

" 2 minutes with a lens of 10-inch focus and $\frac{1}{4}$-inch stop.

" 5 seconds with a lens of 10-inch focus, $3\frac{1}{2}$-inch aperture, with no stop.

" $6\frac{1}{2}$ minutes with a lens of 14-inch focus and $\frac{1}{2}$-inch stop.

" 4 minutes with a lens of 14-inch focus and $\frac{1}{4}$-inch stop.

" $2\frac{1}{2}$ minutes with a lens of 14-inch focus and $\frac{3}{4}$-inch stop.

" $8\frac{1}{2}$ minutes with a lens of 16-inch focus and $\frac{1}{2}$-inch stop.

" $5\frac{1}{2}$ minutes with a lens of 16-inch focus and $\frac{1}{4}$-inch stop.

" $2\frac{3}{4}$ minutes with a lens of 16-inch focus and $\frac{3}{4}$-inch stop.

"7. *Developing the Image.*—The camera back is taken into the operating room, from which all white light is carefully excluded, the plate removed from the camera back, and laid, albumen side upwards, on the fixing stand; as much distilled water is now poured on it as the surface will hold, taking care that *every part of the sensitive surface is covered with the liquid*; allow the water to remain on the surface for one

minute, then pour off and drain slightly; replace the plate on the stand, and pour over the surface, so as thoroughly to cover every part, the pyrogallic solution, which must be *carefully filtered* just before being used; allow this to remain on the plate for one minute, then drain off into a perfectly clean measure, and add to it an equal bulk of silver developing solution; *mix these thoroughly* together with a glass rod, and then pour the mixed liquids over the plate; allow them to rest until the picture begins to appear, which generally takes about from three to five minutes; then pour off and on repeatedly, until the developing fluid becomes opaque, which then contains floating particles, and these, if allowed to do so, would settle on the plate, to the injury of the picture; but this may be prevented by brushing the surface with a camel's-hair brush frequently during the development. When this opacity of the developing fluid takes place, drain all the fluid off the plate, and thoroughly wash with water; then mix another quantity of pyrogallic and silver developing solution in the same proportions as before, and pour this on and off the plate as before, until the picture appears sufficiently intense, and the middle shades well brought out; when this takes place, drain off, and wash with water, so as to clean the surface thoroughly, and the plate is then ready for the next step, 'fixing the image.'

"Should the picture begin to develop in less than three minutes after the application of the mixed developing fluids, thoroughly drain the plate, and wash well with water; then continue the development with a solution of three parts pyrogallic solution, prepared by dissolving fifteen grains pyrogallic acid in seven ounces of distilled water, then adding two drachms glacial acetic acid mixed with two drachms of alcohol and one part silver developing solution, consisting of one drachm nitrate of silver, dissolved in seven ounces distilled water, adding two drachms acetic acid. Should the picture, however, not begin to appear in five minutes, the addition of half a drachm of the albumen bath solution to each ounce of mixed developing solution will be necessary, in order to obtain the middle shades and the required intensity.

"It may be stated, as a guide, that the best negatives which the author has produced occupied from ten to twelve minutes in developing.

"8. *Fixing the Image.*—The plate, having been thoroughly freed from the developing fluid by careful washing, is now placed on the fixing stand, and the surface covered by the fixing solution, prepared by dissolving two ounces hydrosulphate of soda in one pint water. This solution being poured over it, in a few seconds the yellow opalescent colour of the film will begin to disappear, and its complete removal may be hastened by blowing gently on the plate, so as to disturb the fluid.

"When every particle of yellowness has disappeared, the fixing solution is drained off, and the surface *thoroughly washed;* and it is then leaned against the wall to drain and dry.

"9. *Varnishing the Plate.*—The plate, being thoroughly dry, is ready to receive a coating of transparent varnish, in order to protect the albumen surface from injury during the printing process. To do this effectually, the plate must be held before a fire or over a lamp, until it is slightly warm all over; then pour over its surface 'Horne and Thornthwaite's negative varnish,' in the same manner as collodion is applied; allow the superfluous varnish to drain back into the bottle; hold the plate again before the fire until the whole of the spirit is evaporated; and, when cold, the plate is ready to be printed from, so as to produce any number of positive pictures on paper.

"It will be observed that, in describing this process, the operator has been sup-

posed to be so situated, that, in case a second view of the same spot were required, he could return to his operating room, remove the plate which had been exposed from the camera back to the plate box, and place another in the camera back, ready for taking another view. But, unfortunately, this is not at all times practicable. We therefore require some means of removing the plates, after being exposed, from the camera back into the plate box, and substituting others in their stead, whilst we are in the open air.

"In order to effect this, the 'Field Plate Box' has been devised by Mr. Ackland, by the aid of which the plates may be removed from the box, exposed in the camera, and again returned into the box, without any possibility of access of light falling on it.

"This box is but a trifle larger than the ordinary one, and is furnished with two sliding bottoms, working in grooves, one over the other; the lower bottom has a grooved channel, into which the side of the camera back slides; the camera back has an aperture through the side, closed by a narrow slide, and the lower bottom of the field-box has a corresponding one. We now suppose the field-box to have been previously filled with excited glass plates, *having their sensitive sides towards the back of the box*, and the box lid closed. The bottom slide is now pushed on until the aperture is in a line with any particular groove of the field-box (which position is indicated by a numbered scale and index point). The camera back is then slid on to its place on the field-box, so that the hinged flap is towards the front of the box, and its narrow slide drawn out. The upper slide is then withdrawn, and the box inclined, so that the plate in that groove opposite the aperture in the lower slide may pass through into the camera back. When this has taken place, push in the narrow slide of the camera back, invert the box, and push in the inner slide; then withdraw the camera back from its channel, and expose the plate in the camera. When this is done, slide the back again into its channel, draw out the inner box slide, then the narrow camera back slide, invert the box, and the plate will then leave the camera back and pass into the field-box, occupying the same groove as before.

"In order to get out another plate, slide the lower bottom, so that the index points to the number on the scale, as that of the groove in which the required plate is situate. Then proceed as before directed."

Dr. Mansell, of Guernsey, recommends, for changing plates in the open air, a bag made of three thicknesses of yellow glazed calico, one yard wide and one and a half yard long. Into this bag, the plate box containing the sensitive plates, the camera back, and the head, shoulders, and arms of the operator are placed. The bag is then tightly tied around the waist by tapes inserted into its neck. In this the operator can change his plates from the box to the back, or *vice versâ*, with impunity, as the yellow material prevents the admission of any rays that would damage the plates.

The foregoing process will be found very useful to travelling photographers, especially to those who do not use large glasses, as the weight of the latter would be rather an incumbrance; but by means of a light spring hand-cart, that difficulty could be got over. I must say that Mr. Ackland's plan for changing the glass plates, is one of the most ingenious I have ever seen.

Gutta-percha as a Sensitized Medium.—I shall now beg leave to introduce to the reader a new substance in photography, but as I have not had an opportunity of testing its capabilities I must make use of the inventor's words; even this will not be so easy, as it is difficult to say who is the inventor, because, although Mr.

Archer has taken out a patent for the use of the substance, the Rev. Mr. J. B. Reade has communicated the self-same process to the Photographic Journal; and it is rather singular, in reference to patents, that the same gentleman made almost the same discoveries in the calotype that Mr. Fox Talbot made, and actually made them known *before* Mr. Talbot patented his discoveries.

The substance above alluded to is gutta-percha, and the following is the substance of a paper read to the Photograpic Society in November 1855, by Mr. Reade.—

"It is known to many," he says, "that a substitute for glass is a great desideratum to the practical photographer. The cost of glass is a serious diminution to the profits of the professional artist, and loss from breakage, especially when many valuable negatives are destroyed, compels a man to ask whether he cannot be supplied with an article as clear as glass and as tough as leather. I venture to offer gutta-percha as a substitute. It possesses the good qualities of glass in its perfect transparency and evenness of surface, while its cost is trifling, and its cohesion perfect.

"My experiments have recently been carried on in conjunction with my friend Mr. Millar, the resident medical superintendent of the Bucks Lunatic Asylum at Stone, and we can now present gutta-percha in such a form as warrants us to ask for the opinion of photographers upon it.

"In the first place we dissolve gutta-percha in benzole, one of the peculiar hydrocarbons of coal-tar naphtha, or in chloroform. Thirty grains of gutta-percha added to an ounce of either solvent, is poured upon a plate of glass, and the excess drained off into the bottle, as in the use of collodion, produces the film upon which we have worked.

"The benzole dissolved the common sheet gutta-percha of the shops (not a perfectly pure article) with great readiness, upon the application of heat; immersing the bottle in hot water being sufficient. The colouring matter, producing the well-known pinkish tint, fell to the bottom of the bottle, and above it was a solution as clear and colourless as water.

"This was poured upon a glass plate as I have described, and immediately dried, or nearly so, by holding it over a spirit-lamp. This precaution for securing an evenness of surface is more necessary with the benzole then with the chloroform solvent, though its advantage even in the latter case is apparent. The film adheres perfectly to the glass, and has no tendency to separate from it on subsequent immersion in the nitrate bath if the edges of the glass are roughened; but if, as in some cases, they are smooth and polished, it is advisable, when the film is dry, to secure it firmly and certainly by passing the four edges of the coated glass through the flame of a spirit-lamp. By this method about one-eighth of an inch of the film is dissolved, or nearly so, all round the surface of the glass, and no separation can be produced by any amount of immersion in water. This film, now firmly fixed upon the glass, is treated in the subsequent process as if it were glass.

"The iodized collodion is poured upon it and sensitized in the usual way, and the picture is taken, developed, fixed, and varnished. The point of a knife is now carried round the edge of the glass for the purpose of scraping off the small portion of the film which had been semi-dissolved by heat to secure its perfect adherence. It is then placed in water for a minute or two, one edge of the film is slightly raised so that the fingers can take hold of it, and the whole separates with great facility and floats. By raising the glass up to it, it can be taken out on its surface, placed with the film downwards on blotting-paper, and the glass drawn from it. When dry, place the film between two pieces of paper,

held it up to the light and cut the paper—at the same time the film, which is perfectly visible through the paper—to any required size.

"We have now a negative ready for the printing frame, taken on a material as durable and manageable as glass, but occupying only a small portion of its space, and perfectly free from the peculiar risks which so often put valuable negatives altogether *hors de combat*.

"Benzole having the property of becoming solid at a temperature of 32°, the gutta-percha dissolved in it, unless it be a very thin film, has a tendency to become opaque, which might possibly interfere with the subsequent printing from the negative. This defect is wholly avoided by dissolving the benzole film, when dry, in chloroform, and then using the chloroform film, which never becomes opaque, for the purpose proposed. I understand from Mr. De la Rue, that one of the products of Birmese naphtha, which he is about to introduce, will form the best solvent, and produce a thick transparent film at all temperatures. The pure chloroform solution obtained, as above described, may be used, according to the happy suggestion of Mr. Pollock, as a protecting varnish for positives, and if applied to both sides of the picture, injury from atmospheric influence seems scarcely possible.

"I may add that it is not difficult to iodize the solution of gutta-percha itself, taking pictures upon it quite independently of the use of collodion, and also that a mixture of collodion and gutta-percha is not bad; but I think, upon the whole, the proper place for the gutta-percha to occupy is this which I propose, as a substitute for the glass. We then deal with collodion, which is by far the best preparation put into our hands for sensitizing, and upon which we take pictures. We deal with it in the usual way, and put upon the film as if we were putting upon glass. You are then quite independent of glass, and may keep a stock in a small portfolio.

"Perhaps I may be allowed, in addition, to state, that when the film is of a certain degree of thinness it has a tendency, when perfectly dry, to curl; but if you breathe upon it that tendency ceases, and it remains perfectly flat, and can be put into the printing frame with the greatest facility. In taking pictures you would adopt practically a useful thickness."

Mr. Archer says in allusion to his patented process:—"Ever since my introduction of the collodion process, it has been my desire to do away with the inconvenience of glass for negatives.

"According to my early publications, when on a journey, I used to remove the collodion film from the glass, roll the pictures up between blotting-paper, and expand them again on glass when at home; but this occupied much time, and required very delicate manipulation.

"These difficulties induced me to try experiments with a variety of substances likely to preserve the delicacy of the picture on the collodion film, and to be sufficiently strong to bear handling when in use.

"After much labour I have succeeded in my object, and in August last I patented my process, which I hope will be found to remove the only great impediment to the universal use of collodion in photography. The material used is a solution of gutta-percha in benzole. Other solvents can be used, but this is preferable to any.

"There are two methods of applying this solution of gutta-percha (both included in the patent) to accomplish the object in view, viz., the removal of the collodion film from the glass. I will describe them in detail.

"The first method is this:—Pour on the clean glass plate a quantity of the solution

of gutta-percha, in a similar manner as for coating the glass with a film of collodion. When this film is dried, the iodized collodion is poured on and immersed in the silver bath. The plate is exposed, developed, and fixed. The glass plate, with gutta-percha and collodion film attached to it, is immersed in a vessel of cold water, which presently causes the two combined films to separate readily from the glass.

"The second method:—Prepare the glass with iodized collodion, and proceed with the process in the ordinary manner.

"When the collodion picture is dried, pour on to it the solution of gutta-percha; when the plate is covered, hold it in a horizontal position for about a minute to thicken. Draw off very gently through a funnel into the bottle the excess of solution, and gradually raise the plate vertically over the funnel.

"The benzole will evaporate rapidly, leaving on the collodion picture, and in intimate contact with it, a coating of gutta-percha.

"The plate must now be gently held with its back towards a clear fire, to accelerate the hardening of the gutta-percha and to prevent its chilling on the surface.

"When cold, the plate is immersed in a vessel of cold water, which causes the combined films to separate, in one sheet, from the glass."

"In this operation the benzole solution does not come in contact with the glass, nor is the surface of the glass in any way injured by its application to the collodion.

"Thus the glass can be used again after the ordinary cleaning. One great objection to the first method is, if the collodion picture be not successful, the gutta-percha coating is lost; whereas, in the second, the solution is only applied to a perfect picture, or such as the operator wishes to preserve.

"Another objection to the first method is, the great difficulty in getting the gutta-percha film sufficiently even when used thick enough to support the film."

The only objection I see to the process just noticed is, that the gutta-percha film will not stand the heat of a summer's sun, as I have seen solid gutta-percha, and pretty thick too, melt in the heat of summer; and I must say that I should not like to see a negative that I set some value on melt, and perhaps draw out to about twice its length.

It may not be out of place to describe here the camera constructed by Mr. Archer, for out-of-door practice with collodion. It is a wooden box eighteen inches long and twelve inches wide and deep. In front is a sliding door with a circular opening to admit the lens; this sliding door enables the operator to raise or depress the point of view. The camera has in the sides a hole into which sleeves of India-rubber cloth are fixed, furnished with India-rubber bands, into which the hands of the operator are admitted, the bands closing at the wrists and excluding the light while he arranges the collodion frame.

The back of the camera has a hinged door, fitted at its upper part with an opening of just sufficient size for the eyes, and shaped so as to fit close to the face. A black cloth is tied round this end of the camera, to prevent any ray of light penetrating the opening in the top of the instrument. Near the front is inserted a frame of yellow glass hinged like a door to admit a regulated yellow light. The interior of the box is furnished with a sliding frame to support the ground glass, the bath and the prepared plate, with a focusing slide, by which images of from three to fifteen inches can be obtained, the bottom being furnished with a gutta-percha tray, one inch deep, to hold the washings when in operation.

This instrument allows of the preparation of the most sensitive surfaces on the spot, of their immediate use, ready development, and fixing of the image at once.

Mr. Clarke's Siphon.—The following ingenious contrivance of Mr. R. T. Clarke may not be out of place here, he calls it "*A bottle siphon for the silver bath,*" and he uses it for the purpose of emptying his nitrate bath when he has finished working:—

"The upright baths are very awkward things, as made at present, to pour from. I employ a siphon bottle such as is here represented (Fig. 74).

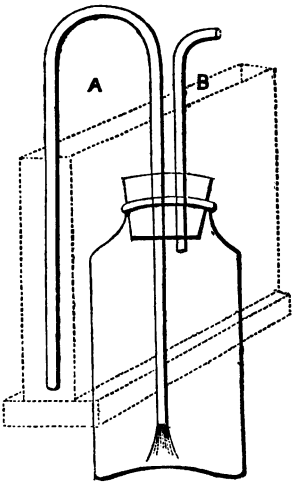


Fig. 74.

"Place the short leg of the siphon A in the bath, which must be raised on a block or otherwise. Exhaust the air from the bottle by the mouth-tube B, and you will draw off your bath into its bottle at once, without danger to yourself or loss of liquid. The lips must be withdrawn of course as soon as the siphon begins to act. You have only now to take out the apparatus, which is merely a cork with two pieces of quill tubing, and replace the glass stopper."

Before dismissing the subject of collodion, I may add, that, with careful manipulation, a total absence of all flurry, performing each part gently, extreme cleanliness, care that there is no floating dust in the camera or dark-room, great care in focusing, proper attention to light and shade, bath, collodion, and developing solution well filtered, measures and vessels well cleaned, absence of any fluid left in the frame by a former plate, gently raising up and shutting down the slide, a proper length of exposure, and, above all, *observation*, success is *certain*. Before concluding, I shall describe a very useful piece of apparatus nearly identical with Mr. Clarke's siphon, which is used by Mr. Hardwich for clearing collodion. The collodion being iodized some hours previously, and allowed to settle down and become clear in a bottle with a large mouth, in which a cork with perforated holes for two glass tubes is placed, as represented in Mr. Clarke's drawing. By gently blowing at the point of the shorter tube, the other glass tube is filled, and the fluid drawn off more closely and cleanly than could be done by simply pouring from one bottle to another. I shall conclude my remarks on this part of the science. The next will be—

On the Fixing and Colouring of Positives.—As this is a subject of vital importance to photography (their being but little use in producing first-rate negatives if you cannot from them obtain beautiful and lasting copies), it has met with an unusual amount of study and experiments at the hands of some of the most eminent photographers. Among these no man has given the subject more consideration than Mr. Hardwich. I again make use of his pages, giving, in some instances, his own words, in others their substance.

This subject Mr. Hardwich divides into five sections:—1st, Positive printing by the ordinary direct process; 2nd, Mr. Sutton's mode of toning positives; 3rd, Positive printing by the negative process; 4th, Remarks on the fading of positives; 5th, On printing enlarged or reduced positives, transparencies, &c., which I shall briefly notice in their turn.

POSITIVE PRINTING UPON CHLORIDE OF SILVER.—This includes preparation of sensitive paper—of fixing and toning baths—manipulatory details of the process.

In the preparation of sensitive paper there are three kinds of surfaces, viz., albuminized paper, plain salted paper, and paper prepared with serum of milk, which may be used. A photographic paper should be very smooth and uniform in texture; of equal thickness in each part, and free from spots. These spots consist usually of small metallic particles, which, when the paper is rendered sensitive, act as centres of chemical action and spoil the effect.

The foreign papers, French and German, are porous and sized with starch, the English being dense and sized with gelatinous animal matter, which gives a brown tint to the reduced chloride of silver in the same manner as albumen. The density of English papers makes the fixing and toning of the positives a slower process than when foreign papers are used. There is also a tendency to curl up when laid upon the liquid for albuminizing, and Mr. Hardwich recommends the thin negative papers of Canson and de la Rive, or the *papier Saxe*, where they can be obtained. A difference in smoothness between the two sides of the paper is perceptible, which may be detected by holding the sheet in such a manner that the light strikes it at an angle; the wrong side is that on which broad wavy bands are seen, caused by the strips of felt on which the paper was dried.

Preparation of Albuminized Paper.—This includes the salting, albuminizing, and sensitizing with nitrate of silver.

Take chloride of ammonium, or pure chloride of sodium fifteen grains, water (distilled if at hand, if not rain water) one ounce.

Mix any number of ounces according to this formula, and add a third part by measure of the whites of new-laid eggs. Then with a bundle of quills tied together beat the whole into a perfect froth. As the froth forms, it is to be skimmed off and placed in a flat dish to subside, when it should form a perfectly homogeneous mass. The success of the operation depends entirely upon the manner in which this part of the process is conducted. If the albumen is not thoroughly beaten, flakes of animal membrane will be left in the liquid, and will cause streaks upon the paper. When the froth has partially subsided, transfer it to a tall and narrow jar, and allow it to stand for several hours, that the membranous shreds may settle to the bottom. Then pour off the upper portion, which should now be clear and fit for use. Albuminous liquids are too glutinous to run well through a paper filter, and therefore it is better to clear them by subsidence.

To apply the albumen, pour a portion of the solution into a flat dish to the depth of half an inch. Then, having previously cut the paper to the proper size, take a sheet by the two corners, bend it into a curved form, convexity downwards, and lay it upon the albumen, the centre part first touching the liquid and the corners being lowered gradually. In this way all bubbles of air will be pushed forward and excluded. One side only of the paper is wetted; the other remains dry. Allow the sheet to rest upon the solution for one minute, and then raise it off, and pin up by two corners. If any circular spots, free from albumen, are seen, caused by bubbles of air, replace the sheet for the same length of time as at first.

Most practical operators lay stress upon removing the sheet from the albumen speedily; and it certainly is the case that if you take a thick porous paper, like Canson's positive, and leave it upon an albumen bath for a long time the surface is roughened and irregular from imperfect absorption of the last layer of liquid.

Albuminized paper will keep any length of time in a dry place. Some have

recommended to press it with a heated iron, in order to coagulate the layer of albumen upon the surface; but this precaution is unnecessary, since the coagulation is perfectly effected by the nitrate of silver used in the sensitizing. Also, it is doubtful whether a layer of dry albumen would admit of coagulation by the simple application of a heated iron.

To Render the Paper Sensitive.—This operation must be conducted by candle or yellow light, and with a solution of nitrate of silver, sixty grains; distilled water, one ounce. If the sample of nitrate of silver contains much free nitric acid it may be of service to neutralize it with carbonate of soda, filtering out the excess of white carbonate of silver, and then adding one or two drops of glacial acetic acid.

Prepare a sufficient quantity of this solution, and lay the sheet upon it in the same manner as before. Three minutes contact will be sufficient with the thin negative paper, but if the Canson positive paper is used, four or five minutes must be allowed for the decomposition. The papers are raised from the solution by a pair of bone forceps or common tweezers tipped with sealing-wax, and hung up to dry. A small strip of blotting-paper suspended from the lower edge of the paper will serve to drain off the last drop of liquid.

After the solution of nitrate of silver has been in use some time, it becomes discoloured from a partial formation of sulphuret of silver. The brown colour may be removed by the employment of animal charcoal, or the white china clay, or "pipe-clay."

After a large quantity of paper has been sensitized, add fresh nitrate of silver in the proportion of about ten grains to the ounce, in order to keep the bath at its original strength.

Sensitive albuminized paper, prepared as above, will usually keep one or two days, if protected from the light; but afterwards it turns yellow from partial decomposition.

Preparation of Plain Salted Paper.—Take of purified gelatine one grain; chloride of sodium or ammonium, ten grains; water, one ounce. Either of the foreign papers may be used for this formula—Canson's positive and papier Saxe being especially recommended. Towgood's positive gives a fine brown nearly approaching to black; it must be salted in the same manner as the others.

Weigh out the proper quantity of gelatine for the required number of ounces, and dissolve it in a small bulk of warm water. Then add the remainder of the water and the salt. The mode of salting the paper is the same as for albumen, but if the weather is cold, it will be well to hang the sheets near to the fire, to prevent any gelatinizing, which might otherwise occur.

Mode of Sensitizing the Salted Paper.—Gelatine paper may be sensitized by floating upon the ordinary sixty-grain solution of nitrate of silver; or with the ammonio-nitrate of silver prepared as follows:—Take of nitrate of silver, eighty grains; distilled water, one ounce. Dissolve the nitrate of silver in one-half of the total quantity of water. Then take a pure solution of ammonia and drop it in carefully, stirring meanwhile with a glass rod. A brown precipitate of oxide of silver first forms, but on the addition of more ammonia it is redissolved. When the liquid appears to be clearing up, add the ammonia very cautiously, so as not to incur an excess. In order still further to secure the absence of free ammonia, it is usual to direct, that when the liquid becomes perfectly clear, a drop or two of solution of nitrate of silver should be added, until a slight turbidity is again produced. Lastly, dilute with water to the

proper bulk. If the crystals of nitrate of silver employed contain a large excess of free nitric acid, no precipitate will be formed on the first addition of ammonia. The free nitric acid, producing nitrate of ammonia with the alkali, keeps the oxide of silver in solution. This cause of error, however, is not likely to happen frequently, since the amount of nitrate of ammonia required to prevent all precipitation would be considerable. From the same reason, viz., the presence of nitrate of ammonia, it is useless to attempt to convert a nitrate bath, already used for sensitising, into ammonio-nitrate.

Ammonio-nitrate of silver should be kept in a dark place, being more prone to reduction than the nitrate of silver.

Sensitising Salted Paper with Ammonio-Nitrate.—Most operators prefer brushing on the solution of ammonio-nitrate, the properties of the solution being altered by the reaction with the salt, free ammonia being thus formed in the ammonio-nitrate bath, which has the effect of changing the half-shadows of the print to a reddish-pink tone. Even in brushing the same ammonia is not to be used too often. Brushes are sold manufactured purposely for applying silver solutions; but the hair is soon destroyed, unless care is taken to keep the brush clean. In sensitising paper by brushing, lay the salted sheet upon blotting-paper, and wet it thoroughly by drawing the brush first lengthways and then across. Allow it to remain flat for a few minutes, in order that a sufficient quantity of the silver solution may be absorbed, and then pin up by the corner in the usual way.

Ammonio-nitrate papers cannot be kept long; they become discoloured after the lapse of a few hours.

Gelatine paper sensitised with plain nitrate of silver will remain good for several days; it turns a little yellow, but this is removed by the toning bath.

Preparation with Serum of Milk.—The serum of milk is prepared as follows:—Take pure milk from the cow, and curdle it by a piece of rennet, or if that cannot be obtained, by dropping into it a little acetic acid or common vinegar. The quantity of vinegar required will, perhaps, be about two or three drachms to the quart of milk, which must be boiling hot at the time the acid is added. The caseine coagulates immediately, and is to be strained out through a cloth and rejected. When the serum has become nearly cold the white of an egg is added, previously beaten up in a cup to insure thorough mixture; then place the serum in a pipkin over a slow fire, and heat it to ebullition. The albumen coagulates, forming a fine network, and carrying up with it globules of oil, thus clearing the liquid. When it is cold, strain again through muslin or calico, and afterwards through blotting-paper. The latter filtration is often tedious, and occupies several hours; if started over night in a large filter, it will probably be completed by the morning. The serum, when properly prepared, should have a straw-yellow tint, and be perfectly clear and transparent.

The serum being thus prepared, take of chloride of ammonium ten grains, of the serum of milk one ounce; to this add one grain of gelatine thoroughly dissolved in a drachm and a half of boiling water; pour the hot solution into the serum, and stir with a glass rod or silver spoon; then add one ounce of alcohol to each ten ounces of the solution.

Sensitising the Serum Surface.—Lastly, measure the bulk of the liquid, and dissolve the salt in the proportion of ten grains to each ounce.

The papers which appear to give the finest tints with serum of milk are Le Rive's negative, papier Saxe, and Canson's positive paper. Towgood's positive paper gives a shade of brown, very warm and pleasing.

The sheets are laid upon the salting bath in the usual way, and allowed to remain from one to two minutes, according to the thickness and degree of porosity of the paper, the thin papers requiring less time.

They are sensitized on the nitrate bath of sixty grains to the ounce of water. From two to three minutes' contact will be sufficient. The serum discolours the nitrate of silver to a certain extent, but not in so marked a manner as albumen.

Papers prepared by this method turn yellow more quickly than usual; they should therefore be sensitized, if possible, only a few hours before use. Mr. Shadbolt recommends the addition of acetic acid to the nitrate of silver bath, to obviate the tendency of albuminized and other papers to discolour by keeping.

Hints in selecting from the above Formulæ.—Albuminized paper is, perhaps, the most generally useful; it gives a warm, bright appearance to the shadows, and the tint is of a pleasing brown.

Serum of Milk Paper gives fine purple tones, and is free from the glossiness of surface which many object to in albumen. Plain salted paper is recommended for obtaining pure black tones suitable for portraits and engravings. The negatives, however, should be intense, or the result will be inferior; good brown tones may be obtained with a comparatively pale negative, but not the finest blacks. Canson's positive paper and papier Saxe are, perhaps, the best for black tints.

Ammonio-Nitrate Paper gives blacks possessing great depth and brilliancy, but it is troublesome to manipulate with, and requires more care than the others.

Preparation of the Fixing and Toning Solutions.—Bath for fixing and toning positive proofs may be prepared in either of the following ways:—By perchloride of iron, with iodine, and with chloride of gold.

1. *With Perchloride of Iron.*—Dissolve four ounces of hyposulphite of soda in seven ounces of water, and thirty grains of nitrate of silver in one ounce of water. Pour into the solution of hyposulphite by degrees, stirring all the time, six drachms of perchloride of iron. The addition of this salt produces a fine purple colour, which soon disappears. When the liquid has become again colourless, which it does in a few minutes, add the dissolved nitrate of silver, stirring briskly. Perfect solution will take place without any formation of black sulphuret.

A toning bath prepared with chloride of iron will be ready for use twelve hours after mixing, but it will be still more active at the expiration of a week. The solution soon becomes acid to test-paper, and milky from a deposit of sulphur; this may be removed by filtration, but it is scarcely necessary to filter out any solid deposit, as the close texture of paper upon which positives are printed prevents it from doing injury.

The bath may be employed either in an acid or neutral state. If the weather is cold, probably the colouring action will be slow, and in that case it is best to allow the acid to remain. But if the thermometer indicates 60° or higher, the colouration of the print is effected with more rapidity, and there is danger of the half-tones being eaten away by the acid bath; and, therefore, it will be advisable to neutralize it by shaking up the solution for five minutes with as much powdered chalk or whiting as will stand upon a shilling, and afterwards allowing it to settle down, or filter it through blotting-paper. Chalk is the only practicable remedy, because the solution contains proto-chloride of iron, which on the addition of an alkali forms first oxide, and then, by reacting on the sulphuretted principles present, sulphuret of iron.

For this reason ammonio-nitrate prints cannot be toned in a solution prepared with chloride of iron.

After the bath has been neutralized, there is a constant tendency to a return of the acidity.

2. *Fixing and Toning Bath with Iodine.*—Dissolve the thirty grains nitrate of silver in an ounce of the water, as before. Then, from four ounces of hyposulphite of soda, weigh out carefully hyposulphite of soda sixty grains. Dissolve in an ounce of the water, and throw into it thirty grains commercial iodine. Agitate the vessel until the whole has disappeared, which will happen in the course of a few minutes. If after the solution of the iodine a brown tint is acquired, there is an excess of iodine; in that case, cautiously add hyposulphite of soda, a single grain at a time, until the liquid becomes colourless; then pour in nitrate of lead forty grains, previously dissolved in an ounce of the water. The addition of nitrate of lead causes the separation of the greater portion of the iodine in the form of yellow iodide of lead, which is useless, and may be rejected. Throw the whole upon a paper filter, and allow it to drain for a short time; then pour upon it by degrees two ounces of water, in order to wash out as much of the soluble tetrathionate of soda as possible. When all has run through, add three ounces of water; dissolve the hyposulphite of soda, and mix in the nitrate of silver solution with continual stirring as before.

This bath is not very active when first prepared, probably on account of a little iodide of lead remaining dissolved; but at the expiration of a few days or a week it will yield very fine tones, and is then superior to Formula No. 1.

It will continue in good working order for about a month or six weeks, but after that time loses its activity to some extent, even if it be not used. The immersion of prints by removing sulphur has the same effect, the tones being produced more slowly, and a fresh addition of iodine being required.

3. *Fixing and Toning Bath with Chloride of Gold.*—Dissolve four ounces hyposulphite of soda in four ounces of water, solution of chloride of gold, a quantity equivalent to four grains, in three ounces of water; thirty grains nitrate of silver in one ounce. Pour the diluted chloride by degrees into the hyposulphite, stirring with a glass rod; and afterwards the nitrate of silver in the same way. This order of mixing the solutions is to be strictly observed; if it were reversed, the hyposulphite of soda being added to the chloride of gold, the result would be the reduction of metallic gold. The difference depends upon the fact, that the hyposulphite of gold which is formed is an unstable substance, and cannot exist in contact with unaltered chloride of gold. It is necessary that it should be dissolved by hyposulphite of soda immediately on its formation, and so rendered more permanent by conversion into a double salt of soda and gold.

A toning bath prepared with chloride of gold is most active at the expiration of a few days after mixing. On keeping for some weeks it loses much of its efficacy by a process of spontaneous decomposition, and requires the addition of fresh chloride of gold.

Photographic Printing.—These include the exposure to light, or printing, properly so called; the fixing and toning; and the washing, drying, and mounting of the proof.

The Exposure to Light.—For this purpose frames are sold, so constructed that they admit of being opened at the back, in order to examine the progress of the darkening by light, without producing any disturbance of position.

Simple squares of glass, however, succeed equally well, when a little experience has been acquired. They may be held together by the wooden clips sold at the American warehouses at one shilling per dozen. The lower plate should be covered with black cloth or velvet.

Supposing the frame to be employed, the shutter at the back is removed, and the negative laid flat upon the glass, collodion side uppermost. A sheet of sensitive paper is then placed upon the negative, sensitive side downwards, and the whole tightly compressed by replacing and bolting down the shutter.

This operation may be conducted in the dark room; but unless the light is very strong, such a precaution will scarcely be required. The time of exposure to light varies much with the density of the negative and the power of the actinic rays, as influenced by the season of the year and other obvious considerations. As a general rule, the best negatives print slowly; whereas negatives which have been under-exposed and under-developed are more rapid.

In the early spring or summer, when the light is powerful, probably about ten to fifteen minutes will be required; but as much as three-quarters of an hour may be allowed in the winter months, even in the direct rays of the sun.

It is always easy to judge of the length of time which will be sufficient, by exposing a small slip of the sensitive paper, unshielded, to the sun's rays, and observing how long it takes to reach the coppery stage of reduction. Whatever the time may be, about the same will be occupied in the printing, if the negative is a good one.

When the darkening of the paper appears to have proceeded to a considerable extent, the frame is to be taken in and the picture examined. If squares of plate glass are used, in place of a printing-frame, to keep the negative and sensitive paper in contact, some difficulty will be experienced at first in returning it precisely to its former position after the examination is complete; but this will easily be overcome by practice. The finger and thumb should be fixed on the lower corners or edge, and the plate raised gently.

If the exposure to light has been sufficiently long, the general aspect of the print appears slightly darker than it is intended to remain. The toning bath dissolves away the lighter shades and reduces the intensity, for which allowance is made in the exposure to light. A little experience soon teaches what is the proper depth to print; but the following general rules may be useful as a guide. The acid toning bath, prepared with iodine or perchloride of iron, dissolves away the lighter shades more than the neutral bath, with chloride of gold. When the proofs are to be immersed for a long time in order to secure black tones, it is necessary to over-print more strongly than when the purple tints are desired.

If, on removal from the printing-frame, a peculiar spotted appearance is seen, produced by unequal darkening of the chloride of silver, either the nitrate bath is too weak, the sheet removed from its surface too speedily, or the paper is of inferior quality.

On the other hand, if the general aspect of the print is a rich chocolate-brown in the case of albumen, a dark slate-blue with gelatine or ammonio-nitrate paper, or a reddish-purple with paper prepared on serum of milk, probably the subsequent colouration will proceed well.

If, in the exposure to light, the shadows of the proof become very decidedly coppery before the lights are sufficiently printed, the negative is in fault. Ammonio-nitrate paper is particularly liable to this fault of excess of reduction, and especially so if the light is powerful; hence it is best, as a rule, not to print by the direct rays of the sun. This point is important also, because the excessive heat of the sun's rays often cracks the glasses by unequal expansion, and glues the negative firmly down to the sensitive paper.

The Fixing and Toning of the Proof.—The print may be immersed in the toning bath immediately on its removal from the frame; but no injury results from putting it aside for a time, if it be kept in a dark place.

After its immersion, move it about for a short time to displace air-bubbles, which, if allowed to remain, produce spots. In a few minutes the rich chocolate-brown or violet-blue tints disappear, and the red tones take their place.

Albumen proofs become brick-red; gelatine and ammonio-nitrate a brownish-black. If the colours are unusually pale and red, very probably the silver bath is too weak, or the quantity of chloride of ammonium used was insufficient; a pink tint in the case of ammonio-nitrate pictures, if very marked, generally gives a bad result. The action of the bath must be continued until the desired effect is obtained. This may happen in from twenty minutes to half an hour, if the solution is in good working order and the thermometer at 60°; but much depends upon the temperature.

The purple tones are an earlier stage of colouration than the black tones, and therefore the latter require more time. It must be borne in mind, however, that prolonged immersion in a tetrathionate bath, prepared with iodine or perchloride of iron, is decidedly favourable to yellowness of the whites; and with an albumen print it will be difficult to obtain pure whites if the colouring is carried beyond the purple stage. With the gold bath the action may be pushed further with impunity.

Ammonia-nitrate and gelatine papers are less prone to turn yellow than paper prepared with albumen. The yellow colour is not often seen decidedly whilst the print is in the bath, but it comes out in the after-processes of washing and drying.

The error most frequently committed in colouring positive proofs is, continuing the action of the hypo bath for too long a time with the idea of obtaining darker tones. The injurious effects so caused are most evident when the print has been washed and dried; it is then seen that much of the brilliancy and richness of the tint is lost, whereas if the proof had been removed at an earlier period it would have been improved. These remarks apply in all cases, but especially so to the tetrathionate bath without gold.

Some advise that on removal from the bath the print should be soaked in new hypo for ten minutes, in order to complete the fixation; but this precaution is not required with solutions of such a strength as those given in the formulæ. An analysis of an old hypo bath, which had been very extensively used, indicated only ten grains of hyposulphite of silver to the ounce, so that it was at that time far from being saturated.

With a bath prepared by the perchloride of iron process, if any red deposit upon the surface of the print (peroxide of iron) occurs during the washing, a portion of the protochloride of iron may be removed from the fibres of the paper by soaking in new hypo.

The addition of fresh crystals of hyposulphite of soda occasionally, in order to keep up the strength of the bath, is a safe plan to adopt, the exact quantity added not being material.

On the Washing Positive Proofs.—It is essential to wash out every trace of hyposulphite of soda from the print if it is to be preserved from fading, and to do this properly requires considerable care.

Always wash with running water when it can be obtained, and choose a large shallow vessel, exposing a considerable surface in preference to one of lesser diameter. Nothing is better than the ordinary leaden sink carefully washed out, and a tube

inserted into the exit pipe, that the water may not flow away until it reaches to the depth of a few inches. A constant dribbling of water must be maintained for about five or six hours, at the end of which time the tap may be stopped, and the print left in the water until the following morning. This is the plan pursued by the author, and found by him to be sufficient for prints toned either with or without gold.

Even in washing by running water, however, some precautions must be observed; the prints should not lie together too closely, or the water does not find its way between them. You may easily prove this by wetting five or six prints fresh from the frame, and, having placed them in a shallow pan of water, turning on the tap until the water runs off quite clear; then separate the papers from each other, when a milky liquid will pass out from between them, thus showing that a stationary layer of fluid existed at that point. Therefore, in washing, the prints should be kept as much as possible separate from each other, and should be constantly moved and turned over to expose every part of the surface to the action of the running water.

When running water cannot be obtained, proceed as follows:—First wash the print gently, to remove the greater part of the hyposulphite solution. Then transfer to a large shallow pan, in which may be placed as many prints as it will hold without laying thickly on each other. Leave them in for about a quarter of an hour, with occasional movement, and then pour off quite dry. This point is important, as the chemist well knows—viz., when washing a deposit to drain off the last portion of liquid completely before adding fresh water. Repeat this process of changing at least five or six times, or even more, according to the bulk of water, number of prints, and degree of attention paid to them. Lastly, place them together in a larger vessel of water, and allow to soak for several hours, stirring occasionally. Then blot off with filtering paper, and hang up to dry.

Drying.—The fluid which drains from the edge of a washed print may be tested for hyposulphite of soda, by touching with a rod dipped in solution of protonitrate of mercury; a black colour, which is sulphuret of mercury, indicates the presence of hyposulphite. The common plan of tasting the lower corner for the sweet hyposulphite of soda and silver is now thought by the writer to be insufficient.

When the print is nearly dry, it is recommended by some to place it between two layers of blotting-paper, and press with a moderately hot iron. This appears to darken the tint slightly if produced in a feeble colouring bath, but when the bath is active it causes but little appreciable change.

Albumen proofs when dry are sufficiently bright without further treatment; but in the case of plain paper, salted simply, or with serum of milk, the effect is improved by laying the print face downwards upon a square of plate glass and rubbing the back with an agate burnisher, sold at the artist-colourman's. This hardens the grain of the paper and brings out the details of the picture.

Mounting.—In mounting the proofs, be careful not to employ sour paste, which may possibly injure the tint, and keep them in a place free from damp and mould. Thick gum-water answers very well as a cement, or gelatine dissolved in hot water. Some use caoutchouc dissolved in mineral naphtha, which has the advantage of drying speedily, and does not make the card board cockle up.

Mr. Sutton's Process for Toning Positives.—This process was communicated to the Photographic Journal in the month of March, 1855. It is somewhat more troublesome than the plans ordinarily followed, but possesses advantages which will

presently be enumerated. The description may be divided into preparation of the toning bath and manipulatory details :—

"*Preparation of the Toning Bath.*—Dissolve chloride of gold one grain, and hyposulphite of soda three grains, each in two ounces of distilled water; then mix quickly by pouring the former solution into the latter, and add five minims hydrochloric acid. If the chloride of gold is neutral the liquid will have a red tinge, but if acid, then the solution is colourless.

"In place of making an extemporaneous hyposulphite of gold by mixing the chloride with hyposulphite of soda, Mr. Sutton employs the crystallized sel d'or, half a grain to the ounce of water, acidified as before, but the objection to the use of this salt is its expense, and also the difficulty of obtaining it in a pure form; some samples containing no more than five per cent. of gold.

"The quantity of solution given in the formula is sufficient to tone more than a dozen prints of five inches by four; and, therefore, as chloride of gold is sold at twopence per grain, this process cannot be objected to on the score of economy.

"The bath is most active when first prepared, but it will keep for some time, provided the prints be properly freed from soluble nitrate of silver.

"The paper may be prepared by either of the three formulæ given by Mr. Hardwich, according to the tint desired. The printing is not carried quite to the usual intensity, as the gold bath dissolves the half-tones scarcely or not at all.

"On coming from the frame the prints are washed thoroughly in common water until it ceases to become milky; which will not happen until the greater part of the nitrate of silver is removed. The washing must be conducted in a dark place, but it is not necessary to hurry it; the proofs may be thrown into a pan of water covered with a cloth, and allowed to remain until required for tinting.

"A trace of free nitrate of silver usually escapes the washing unless it has been done very carefully and with hot water. This would cause a yellow deposit (probably hyposulphite of silver or a salt of a similar kind, mixed with metallic gold) on the print, and also in the toning bath. It must, therefore, be removed either by adding a little salt to the water during the last washings, or better still by means of a dilute solution of ammonia.

"To prepare this alkaline bath, take liquor ammoniæ one drachm, common water one pint. The exact quantity is not material; if the liquid smells of ammonia it will be sufficient.

"Place the washed prints in this bath, two or three at a time and allow to remain until the evanescent purple tint begins to give place to a red tone. The action must be watched, because if the ammonia bath is strong the proof soon becomes pale and red, and when that is the case you lose a little brilliancy in the after tinting. Albuminized and English papers, from their dense structure, require a longer time in the ammonia than porous papers simply sorted.

"With ammonio-nitrate prints this bath may be omitted; the proofs being transferred to the toning solution immediately after washing.

"As chloride of silver is comparatively insensitive to light, when the excess of nitrate is washed away, it is not necessary to darken the room; but a bright light proceeding from an open door or window should be avoided.

"The ammonia having done its work, soak the prints again for a few minutes or longer in common water to wash out the alkali. Then place them in the toning bath of gold and acid; do not put in too many at once, and move them about occasion-

ally to prevent spots of an imperfect action at the point where the sheets touch each other.

"The foreign papers, plain salted, colour rapidly in two or three minutes. English papers require from five to ten minutes; albuminized, ten minutes to a quarter of an hour.

"By removing the print before the deposit of gold has fully taken place, you obtain a dark red-purple tint, and by a longer action a violet purple approaching to black. When this tone is reached a continuance of the action produces but little change; there is a slight diminution of brightness, but not that yellow tint so commonly seen with old and acid hypo baths.

"The toning being completed, the prints are again placed in water (the same used for washing out the ammonia does very well) to remove the greater part of the acid. This washing must not be continued longer than five or ten minutes, or there will be a danger of decomposition of a salt of silver, producing a yellowness of the whites; this, however, ought never to happen with proper precautions.

"Lastly, the proofs are fixed in a new solution of hyposulphite of soda, one part to four of water. This bath alters the tone slightly. In the case of ammonio-nitrate prints the purple black passes by degrees to a black almost pure.

"In order that the fixing may be properly performed, the time of immersion should not be less than ten minutes with a porous paper, plain salted, or fifteen to twenty minutes in the case of an English or albuminized paper.

"It will sometimes happen in this process, from the toning bath having but little solvent action on the light shades, that the prints, after being washed and dried, appear too dark; this may be remedied by laying them for a few minutes in a very dilute solution of chloride of gold, and washing for an additional quarter of an hour. Five or six drops of solution of chloride to a few ounces of water, not enough to change the colour of the liquid, will suffice.

"*Advantages of Toning by this Process.*—1. The toning solution can be prepared in a few minutes with its full amount of efficacy, and will yield a similar tint any number of times successively. On the other hand, fixing and toning baths of hypo and gold, by the continued immersion of prints, alter in composition, and in their action upon the print, almost daily.

"2. The free nitrate of silver is removed from the print before it enters the fixing bath; hence the purity of the whites is very perfectly preserved.

"3. Bronzing of the deep shadows of the print is removed very perfectly.

"4. Overprinting is scarcely or not at all required.

"5. A pure black and white tint can be obtained with certainty, if the negative is sufficiently intense, by printing upon plain salted paper or ammonio-nitrate paper."

Positive Printing by the Negative Process.—The negative process for printing positives will be found useful in the dull winter months, and at other times when the light is too weak to act directly upon chloride of silver:—

"A very good iodized paper for illustrating the development of a latent image may be made as follows:—Take of

Iodide of potassium	10 grains.
Water	1 ounce.

Float the paper on this solution in the ordinary manner, and hang up to dry; then by yellow light render it sensitive upon a bath of the following strength:—

Nitrate of silver	80 grains.
Acetic acid (glacial)	30 minims.
Distilled water	1 ounce.

Three minutes' contact will be sufficient; after which dry thoroughly, carefully excluding all rays of white light.

"Develop with a saturated solution of gallic acid, which may conveniently be applied by the ingenious contrivance of Mr. Buckle, already described. Ordinary camel's-hair brushes are quickly destroyed by the mixture of gallic acid and nitrate of silver, unless kept scrupulously clean.

"Gallic acid is soluble in about one hundred parts of cold water; therefore, to prepare a saturated solution, add five grains to each ounce, and apply a gentle heat. The aqueous solution decomposes, and becomes mouldy by keeping; this may be partly obviated by adding acetic acid (a drachm of the glacial acid to twelve ounces of the solution), or by a drop or two of oil of cloves.

"*Sir W. Newton's Process for Printing Positives.*—Bromide of potassium or calcium is used in place of iodide of potassium, as yielding a better tint and more purity of the white parts of the picture. Take of

Bromide of calcium	10 grains.
Gallic acid	5 grains.
Water	10 ounces.

"Cut up a bit of camphor of the size of a nut into small pieces, and digest it with the water for twelve hours, to obtain a saturated solution. Then add two or three lumps of white sugar, the gallic acid, and the bromide, as advised in the formula.

"Apply the solution to the paper by brushing, and when dry, excite with the following bath:—

Nitrate of silver	12 grains.
Acetic acid (glacial) . . : .	20 minims.
Distilled water	1 ounce.

This solution must be applied by brushing, since, in adopting the ordinary plan of floating, the bath would be discoloured by the gallic acid in the paper.

"The following directions are given for the exposure and development of the picture:—Expose to the light (not sun) in the printing frame until a slight change takes place in the colour of the margin—from half a minute upwards, according to the light. A very little experience will, however, regulate this point. After which develop by immersion in gallic acid (of course in a yellow light) ten grains to ten ounces of distilled water, in a flat dish, as many as ten or a dozen at a time. During the process of developing, a small quantity of aceto-nitrate of silver may be added, occasionally gently agitating at the same time.

"Unless Canson's paper be albuminized, it will not answer the object; if, however, it be albuminized, it should be floated over the different solutions. I do not like the French paper, but much prefer Whatman's."

Mr. Sutton's Negative Process.—The paper is prepared with serum of milk, with or without bromide of potassium. The serum is used to impart a warmer tone to the reduced silver than that obtained on plain paper.

"In the preparation of serum of milk, Mr. Sutton advises to separate the caseine by rennet (previously washed to remove salt), in preference to using acetic acid. The

serum must be filtered very carefully. The papers are immersed several at a time, and subsequently hung up to dry. The addition of bromide of potassium, five grains, to each ounce of serum, greatly increases the sensitiveness of the paper.

"Aceto-nitrate of silver is used in sensitizing, prepared by the following formula:—

Nitrate of silver . . .	20 to 30 grains.
Acetic acid (glacial)	30 minims.
Distilled water	1 ounce.

Immerse the papers, taking care that both sides are evenly wetted, and allow to remain three minutes; then hang up to dry in a perfectly dark place.

"The development is conducted by immersion in solution of gallic acid, either saturated, or if that should act too quickly, as it will sometimes do in hot weather, the same diluted with an equal bulk of water. This part of the process occupies about five minutes.

"*Remarks on Printing by the Negative Process.*—Mr. Hardwich advises the amateur to master the manipulation of the ordinary positive process before trying that by development. Perfect cleanliness is most essential, and the solutions should all be filtered with care to free them from fine particles in suspension, which would cause spots.

"White light must be excluded with all the precautions exercised in the case of collodion negatives.

"The exposure to light is conducted in the ordinary printing-frame; it extends from a few seconds upwards. On removing the negative a very faint image is seen, which develops rapidly when the gallic acid is applied.

"The development being completed, the prints are well washed and fixed in hyposulphite of soda, one part to four of water. The tint is improved by adding a little nitrate of silver (a few drops of the exciting bath) to the gallic acid towards the end of the process; but a better plan is to tone the prints in the gold bath, described at page 245, before fixing.

"In that case, after developing, they must be well washed, then placed in salt and water, or in dilute ammonia, and afterwards toned and fixed in the manner already fully described.

"The appearance of prints taken by the negative process is artistic and good; but it is difficult to get the same elaborate definition and clearness of shadow, as by the ordinary positive process upon chloride of silver."

On the Fading of Positive Proofs.—The fading of paper positives has long been a source of annoyance to photographers; a gradual loss of brilliancy and a yellow tint is seen to commence at the margins and half-shadows of the print, and to extend by degrees over the whole surface.

"This matter has of late become of such importance that the council of the Photographic Society decided a few months since upon appointing a committee, of which the writer has the honour of being a member, to examine and report upon it.

"The experiments required, in order to be decisive, must necessarily extend over a long period of time, and it will be many months before the results can be fully known. The proofs which fade most frequently are those which have been fixed and also toned. It is this part of the process, so necessary to the artistic effect, which increases the danger.

"If a positive picture, as taken from the frame, be immersed in a solution of old hyposulphite, that is, hyposulphite associated with a compound containing loosely combined sulphur—and when properly tinted, be removed and hung up to dry without any previous washing, it soon turns yellow and becomes altogether pale and faint. Some have thought that the change is caused by the black sulphuret of silver absorbing oxygen and being converted into sulphate of silver; but this cannot be, because a solution of an alkaline sulphuret, which blackens sulphate of silver, has no effect in restoring the original colour of this yellow substance.

"It appears more probable that the yellow fading is due to an excess of sulphuration, or of sulphuration and oxidation combined.

"The action of sulphuretted hydrogen gas or an alkaline sulphuret upon darkened chloride of silver has been studied by more than one observer. It first blackens the brown tone and then changes it to a greenish-yellow. This indeed is the same effect as that produced by the ordinary sulphuretted hypo toning bath, which always causes yellowness when too long continued."

If we then bear the fact in mind that an excess of sulphur destroys the print, it will be easy to understand some of the more obvious causes of fading. Some of these causes, in an abbreviated form, I give from Mr. Hardwich's "Chemistry of Photography."

Imperfect Washing.—This, he says, is the most important of all, and the most frequent. If hyposulphite of soda, even in minute quantity, be allowed to remain in the print it will certainly cause fading. In that case you have sulphur liberated by a slow process of spontaneous decomposition; and the sulphur acting, alone or in conjunction with oxygen, on the already sulphuretted print, turns it yellow.

Dilute fixing and toning baths are often preferred from their yielding very brilliant tints; but it cannot be shown that their employment is unscientific and wrong. Upon the surface of the print, as it comes from the frame, there is much free nitrate of silver, which, when immersed in the fixing bath, forms hyposulphite of silver, a spontaneously decomposing salt. This should be dissolved immediately by an excess of hyposulphite of soda, if it is to be rendered permanent. Therefore if a bath is prepared so dilute as to contain only one part of hypo to about six or eight parts of water, the strength of the solution being insufficient, a shade of brown may be observed passing over the surface of the print on its first immersion, and a large deposit of sulphuret of silver soon forms as the result of this decomposition. On the other hand, with a strong hyposulphite bath there is little or no discolouration and the black deposit is absent.

The most scientific mode of printing is, no doubt, that in which the nitrate of silver is washed out of the proof immediately on its removal from the frame. This point being attended to, a picture is obtained with the lights pure and free from any salt of silver, which may be proved by subsequent immersion in hydrosulphate of ammonia, whereas in the ordinary process there must be decomposition more or less at every part of the surface, as shown by the rapid change of properties which the bath of new hyposulphite experiences.

On Mounting Proofs.—All cements that are of an acid nature or liable to spontaneous decomposition should be avoided. Sour and mouldy paste is very objectionable, but even this is better than paste containing corrosive sublimate, and sold as "everlasting."

Light and Moisture as Causes of Fading.—The print should certainly be kept in a dry place, free from damp and mouldiness; on this all are agreed. The exact action

of light, however, upon paper positives is not so well known, although it is generally considered that they retain their brilliancy more perfectly when exposure to bright light is avoided. This point is one to which the attention of photographers is especially directed.

Toning without Gold.—It has been said that the prints toned in hyposulphite of soda containing no gold invariably fade; but such a statement cannot be substantiated, since many are in the possession of photographers of that kind which have stood for years. The coloured surface of a merely sulphuretted print is easily susceptible of injury, since the simple pressure of the warm hand (leaving behind probably a little acid) will often produce a yellow mark. The employment of gold salts in photographic printing, however, by causing a deposit of metallic gold, increases the chance of permanency under unfavourable conditions.

The process of M. Le Grey with chloride of gold used alone, and that of Mr. Sutton with the hyposulphite of gold and hydrochloric acid, are both likely, on theoretical grounds, to give great permanency. The toning bath in both cases is acid to litmus-paper, but the acidity is different to that generated by old hyposulphite of soda, and does not tend to produce yellowness of the proof.

Negative Printing as Obviating Fading.—If the print be simply developed by gallic acid, and afterwards fixed in solution of hyposulphite of soda newly made, it would then be in the condition of an ordinary calotype negative, which the experience of many years has shown to be permanent. But it is difficult to obtain brilliancy of tone by this mode, and if a gold bath be used to darken the shadows, the case is altered. A developed print, toned and fixed, may be more indestructible than one obtained by the ordinary process.

"The following is a simple plan by which the permanency of a positive proof may often be tested. Lay the washed print, whilst still damp, upon a clean sheet of glass, and allow water to drip slowly upon it for twenty-four hours; if it retains its brilliancy unimpaired at the end of that time, it may be considered permanent. A convenient plan is to fill a small basin with spring water, and to hang a piece of stout cotton over the side; this acts as a syphon, and keeps up a constant dropping. The action of the air and water together will produce fading and yellowness, if the picture is not properly washed.

On Printing Enlarged and Reduced Positives.—If a collodion negative be placed at a certain distance in front of a camera, and, by a tube of black cloth or some similar contrivance, the light be admitted into the dark chamber only through the negative, an image will be formed upon the ground glass which is reduced in its dimensions; but if the negative be advanced nearer, the image will increase in size until it becomes first equal to, and then larger than, the original negative. At the same time, it is formed at a point more and more distant from the lens; that is, it recedes as the negative is brought nearer.

Again, if a negative portrait of a sitter be placed in the camera slide, and the instrument being carried into a dark room, a hole be cut in the window-shutter so as to admit light through the negative, the luminous rays, after refraction by the lens, will form an image of the exact size of life upon a white screen placed in the position originally occupied by the sitter. These two planes in fact, that of the object and of the image, are strictly conjugate foci, and, as regards the result, it is immaterial from which of the two, anterior or posterior, the rays of light proceed.

Therefore, in order to obtain a reduced or enlarged copy of a negative, it is

necessary only to form an image of the size required, and to project the image upon a sensitive surface either of collodion or paper.

A good arrangement for this purpose may be made by taking an ordinary portrait camera, and prolonging it in front, by a deal box blackened inside and with a double body to admit of being lengthened out as required, or, more simply, by a framework of wood covered in with black cloth; a groove in front carries the negative, or receives the slide containing the sensitive layer, as the case may be.

In reducing photographs, the negative is placed in front of the lens, in the position ordinarily occupied by the object, but in making an enlarged copy it must be fixed behind the lens, or, which is equivalent, the lens must be turned round so that the rays of light, transmitted by the negative, enter the back glass of the combination and pass out at the front. Mr. Shadbolt, who has given attention to the subject, shows the necessity of attending to this point, in order to avoid indistinctness of image from spherical aberration.

A portrait combination of lenses of two and a half or three and a quarter inches is the best form to use, and the actinic and luminous foci should accurately correspond, as any difference between them would be increased by enlarging. A stop of an inch or an inch and a half aperture placed between the lenses obviates to some extent the loss of sharp outline usually following enlargement of the image.

The light may be admitted through the negative by pointing the camera towards the sky; or direct sunlight may be used, thrown upon the negative by a plane reflector. A common swing looking-glass, if clear and free from specks, does very well; it should be so placed that the centre on which it turns, is on a level with the axis of the lens.

The best negatives for printing enlarged positives are those which are distinct and clear; and it is important to use a small negative, taken at a considerable distance, which strains the lens less, and gives a better result in every way than one of larger size. In printing by a two and a quarter lens, for instance, prepare the negative upon a plate about two inches square and afterwards enlarge it four diameters.

Paper containing chloride of silver is not sufficiently sensitive to receive the image, and therefore the print must be formed upon collodion, or on iodized paper developed by gallic acid.

The exposure required will vary greatly, not only with the intensity of the light and the sensibility of the surface used, but also with the degree of reduction or enlargement of the image.

In printing upon collodion, the resulting picture is positive by transmitted light; it should be backed up with white varnish, and then becomes positive by reflected light. The tone of the blacks is improved by treating the plate first with bichloride of mercury, and then with ammonia.

ON THE DAGUERREOTYPE.

I have already stated, in the brief history of this discovery, the circumstances under which it originated and acquired its name from one of the original discoverers. The Daguerreotype picture is taken on a copper plate, with a silvered surface. We have seen that the paper process, and afterwards the glass plate coated with various

organic substances, have gradually superseded the silvered plate, especially in this country; but as a branch of Photographic Art it forms an important chapter.

The beautiful process by which the Daguerreotype picture is obtained, was published to the world in July, 1839, after the French government of the day had rewarded M. Daguerre with a pension of 6000 francs, and M. Isidore Niepce, the son of his colleague in the discovery, with another of 4000, with a half in reversion to their widows—a liberal endowment, worthy of imitation on the part of the British government on similar occasions. The process divides itself naturally into six operations, which we shall describe in the following order:—

Preparing the Plates.—The object in this operation is to obtain a perfectly pure and polished surface of silver; it is therefore of the greatest importance that the articles used, in the latter part of the process, should be perfectly free from grease, or any other article of a fixed oily nature. Many ways and substances have been proposed for these purposes; but the following methods I have generally found produce the best results, they are most simple in their details. The materials required are calcined tripoli, prepared lampblack, rouge, and olive oil.

There are several varieties of these plates, under the names of English and French, manufactured, as the names import, in those countries. The plates manufactured in England are generally thicker and have more silver on them than the foreign, from which circumstance they receive a finer surface, and are more useful for beginners, as they will bear cleaning for a great number of times. The French plates, being cheaper than the English, can be employed when practice has enabled the operator to be nearly certain of his results. They are usually marked 1·40 and 1·30, indicating the thickness of silver on them, and consequently their quality; those marked 1·40 will scarcely admit of being used a second time, but the other may, perhaps, with care, be polished three or four times without removing the silver altogether.

In the preparation of plates, hammering seems to be absolutely necessary, binding together, as it were, the materials of the metal; but to be effective it requires to be done with skill, intelligence, and much care. The anvil, as well as the hammer, requires to be very slightly rounded, so that each stroke produces a smooth and even surface, wtthout cavities. It is also necessary to have near the anvil a pair of bellows, which the operator can move with his foot, and from which a blast of wind is thrown upon the surface of the plate, which has the effect of removing any grains of the metal, or other corpuscles raised either by action of the hammer or of the atmosphere. The hammering, when accomplished in this manner with a deposit of silver sufficiently thick, renders the plate capable of the highest polish.

Coating the Plates.—In reference to the Daguerreotype plates of commerce, and the necessity of the silver of the plate being chemically pure, the following experiment of M. le Baron Gros, is conclusive. Having procured a new plate, double silvered in the ordinary manner, he plunged one half of the plate into a galvanic trough, and gave it a fresh coating of pure silver, submitting it afterwards to the usual preparations. The image obtained on the plate presented the following characteristics:—In the part of the plate which was left in its original state, the image was scarcely visible, while that portion which had received the galvanic deposit, presented a fully developed picture.

This experiment of the Baron Gros was highly satisfactory to the Daguerreotypist, inasmuch as it not only teaches him how to render an imperfect plate useful, but how

he may use any old plates. It is not necessary to give the reader all the details of the process here, seeing he can refer to Mr. Gore's treatise on Electro-deposition; but I shall briefly detail the process adopted by the Baron, referring to Mr. Gore's treatise for the principles.

If the plate is a new one, which it is wished to renew or increase the silvering, the process commences by drilling small holes in two of the corners of the plate, for the purpose of suspending it in the solution; the back of the plate is now to be varnished all over with a non-conducting varnish, either copal or sealing-wax dissolved in naphtha will serve the purpose.

The form of battery now most universally employed for electrotype and other galvanic purposes is Smee's (Fig. 75). It consists of a piece of platinized silver, A, on the top of which is fixed a beam of wood, B, to prevent contact with the silver. The binding screw, C, is soldered on to the silver plate, to connect it with any desired object by means of the copper wire, C. A plate of amalgamated zinc, D, varying with the fancy of the operator from one half to the entire width of the silver, is placed on each side of the wood. This is set into a glass vessel, P, the extreme ends of the wood resting upon its edge, on which the acid with which it is charged has no effect. The jar is charged with sulphuric acid (common oil of vitriol), diluted in eight parts its bulk of water. The zinc plates of the battery have been amalgamated with quicksilver, and when the battery is set into the jar of acid, there should be no action perceived upon them when the poles, F, G, are not in contact. Should any action be perceived, it indicates imperfect amalgamation; this can be easily remedied by pouring a little mercury upon them immediately after removing them from the acid, taking care to get none upon the centre plate A.

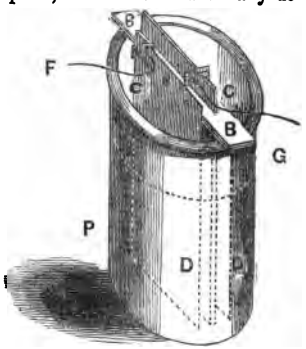


Fig. 75.

Directions for Use.—A sheet of silver must be attached to the wire connected with the centre plate, A, of the battery, and placed in the silver solution—prepared as directed below. The plate to be silvered is first cleaned with diluted sulphuric acid, and then attached to the wire, G, proceeding from the zinc plates, D, D, and placed in the silver solution, opposite the silver plate attached to the pole, F, and about half an inch from it. A slight effervescence will now be perceived from the battery, and the silver will be deposited upon the Daguerreotype plate, while at the same time a portion of the silver plate is dissolved.

To Prepare the Solution of Silver.—Dissolve one ounce of chloride of silver in a solution of two ounces of cyanide of potassium, previously dissolved in one quart of water. The oxide of silver may be used instead of the chloride. This solution is put into a tumbler or other vessel.

Polishing the Plates.—To polish Daguerreotype plates so as to make them perfect, requires two distinct conditions—one mechanical, the other chemical: the perfecting of the metallic surface, and the exquisite cleanliness requisite to insure the purity of the silver surface which is to receive the photographic image. The importance of chemical purity has already been shown.

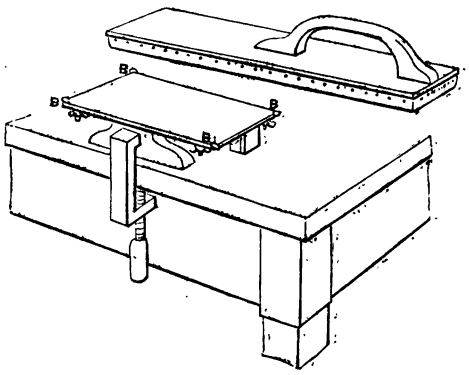
Many fanciful theories were formed on the subject of preparing the surface of the

plate for receiving the Daguerreotype. MM. Belfield and Foucault attributed their own success to a coating of organic matter, which diffused itself over the plate; and M. Daguerre himself fancied he had discovered a galvanic action in a combination of three or four metals, which favourably disposed the plate to receive the coating of iodide of silver and bromine, but experience soon demonstrated the inefficacy of his fancied discovery. Let us then throw aside all these theories. Every mode of polishing, whatever it may be, that insures to the plate a perfectly smooth surface, and great chemical purity, may in practice be adopted without inconvenience. Among the methods of polishing which have received the sanction of experience, we shall describe those only which are simple and efficacious.

The Polishing Table.—Formerly, when about to polish, following the instructions of M. Daguerre, it was thought sufficient to place the plate on several sheets of paper, which were renewed as soon as soiled, and kept in its place with the fingers of the left hand, while the right directed the pledget of cotton. These means were soon found insufficient, and a small polishing board, fixed on a table by means of a small press, was devised. The plate was fixed on this board by means of two small copper catches, whose raised extremities were pierced by a small groove, to which the corners of the sheet of the plate were fixed. M. Levret was the first who conceived the happy thought of substituting for the raised edges of the copper catch a small flat metallic button at each corner of the plate. By this contrivance, now generally adopted, no obstacle opposes the action of the pledget of cotton, or other polisher used.

Figure 77 represents the polished board under this last form; its surface is of rather smaller dimensions than that of the plate, and it is covered with a piece of thick cloth or flannel fixed to it with strong glue. This precaution is indispensable to insure the perfect contact of the plate with the board. At the corners of the small board four little copper grooves will be observed, B, B, B, B, each surrounded with a small flat button of the same metal. Under each of these is fastened a corner of the plate. Four little bolts, provided with screws and handles, are placed underneath the board, which permit it to be moved backward and forwards, and adjusted according to the will of the operator.

Fig. 77.



The cotton-velvet polishers employed by M. Claudet, and even those of deer-skin since adopted, would quickly be spoiled by the sharp edges of the plate, if care were not taken to turn down the edges in such a manner that the polisher cannot be caught by them. This simple operation is performed with the assistance of a steel burnishing stick. A small board of wood is taken, furnished with a steel ruler, while the cut-

ward edge is covered with leather. The plate is disposed upon this board, the silvered face up, so that its edge is in contact with the sharp cutting of the steel ruler. Passing the burnishing stick over it once or twice round the edge of the plate sufficiently for the purpose. This operation is of course repeated all round the plate. The four corners of the plates are now placed, by means of flat pincers, under the four buttons of the polishing board.

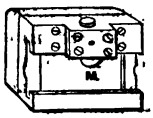


Fig. 78.

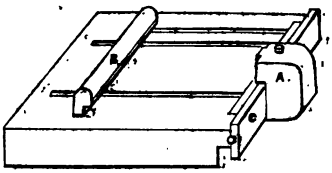


Fig. 79.

Figures 78 and 79 represent a very useful machine for the operation just described; it consists of a wooden frame furnished with a steel ruler. The outside edge of this shelf has a second ruler of iron, or of hard wood, perpendicular to the first, which serves to guide the plane A (Fig. 79). In Fig. 79, the letter B indicates a moveable cheek of wood, which serves to adjust the plate, and prevents it from moving backward while the plane is in action. The use of this plane is easily understood; a small pair of steel nippers in Fig. 78, which cuts at an angle, and which acts concurrently with the steel rule, is fixed on the board, and serves to depress the edge of the plate.

And now let us give our attention to the polishers. Fig. 76 represents one of these; it consists of a small board of soft wood, from twenty to twenty-four inches in length and about six broad, and in thickness about one and a half, furnished with a handle a little resembling that of a joiner's plane. Over this board is stretched, by means of some carpet nails, some thickish material like flannel. Over this again is placed a very fine sheet of pasteboard, and over the whole a piece of white cotton velvet or doeskin, firmly nailed to the edges of the board. Four polishing brushes, two of velvet and two of deer's-skin, stretched tightly over them, are required; and, we need not add, these polishing instruments require extreme cleanliness, and should be carefully put away, each in their separate box, every time after being used.

M. le Baron Gros recommends for the first operations of polishing, small pledgets of his own contrivance, the use of them are both simple and economical. In Fig. 80, is seen the model of one of these pledgets, or dabbers, which may be made in wood. The square part is finished with a thick surface of India-rubber, over which a small square of cotton velvet is arranged, which is renewed whenever it is required. This square of velvet, whose opposite corners press against the contracted parts of the pledget, is kept in its place by the fingers of the operator, the round stuffed part of the pledget being placed in the palm of the hand.

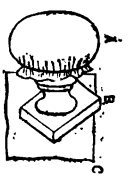


Fig. 80.

After numerous experiments in which nearly all the substances that can be reduced to fine powder, have been successively tried, the greater part of them have been abandoned, and tripoli powder, blacklead, and English rouge are almost exclusively used. It is known that a perfect polish is not easily obtained with pumice-stone and tripoli, for, besides the difficulty of a trick of using the hand that is not easily acquired, these substances, such as we can procure them in commerce, even when washed, are far from being in a state of sufficient purity to produce the required surface on the silvered plate. It is thus necessary to subject these substances to a new washing and decantation. This is performed as follows:—

Into a large decanter or glass jar filled with water, pour a handful of pumice-stone or of tripoli powder; shake the glass well, then let it remain for four or five minutes to settle the pumice stone, and two or three for the tripoli; then by introducing a syphon into the glass, the lower end of which should not be dipped more than half the depth of the liquid, the water containing in suspension the thinnest particles of the pumice-stone, as tripoli is drawn off; when this powder is half dry, it is placed in a porcelain crucible, or if there is no crucible at hand, in the top of an earthen pipkin, and a strong heat applied by means of a spirit lamp. It is not necessary, however, to carry this calcination to a red heat; it is sufficient that the powder is quite free from moisture. With pumice stone or tripoli powder thus prepared, a perfect polish may be obtained; but to give the last touch to the plate, and so burnish it to an intense black, it is necessary that English rouge should be used, and it is well to be very particular as to its quality.

Polishing powders should be shut up in small glass bottles, with a large opening, and the orifice closed with a metallic gauze; thus the inconvenience of soiling the fingers will be avoided. These bottles should be carefully shielded from moisture; and it is best in damp weather to place them near the fire, that the enclosed powders may be well dried.

The plate being fixed to the polishing board, two or three drops of essence of turpentine are poured over it, and a little prepared pumice and tripoli added, with a cotton pledget that need not be new, rub round and round, forming a number of small circles very near but not touching each other, carefully going equally over every part of the surface. After about a minute a black greasy substance will be formed on the silver, of which the largest part must be removed, continuing to rub round with the same cotton. After a time add a small quantity of dry pumice or tripoli to the plate, and with a new pledget rub on, still in a circle, till the surface of the plate takes a vivid brightness. This is the first stage of the work.

Arrived at this point, pour over the plate three or four drops of a mixture of essence of turpentine, and of alcohol in the proportion of one part of alcohol to half of turpentine; to this add a little pumice or tripoli, spreading it lightly over the whole surface of the plate, with the same pledget used in the preceding operation. When this coating of tripoli is spread regularly over the surface let it dry. There will then form upon the plate a thick crust of a dead white colour; in less than a minute the drying is completed; and to finish polishing there is only the coating of tripoli to be removed.

For this purpose a new pledget is taken, and this time the plate is rubbed in a contrary direction; in a very short time the burnishing will be perfect, and the plate ready for iodizing.

The process just described saves much time, and can be applied to all plates, whether they are new or have been previously used. The essence of turpentine having been once employed, it would appear that no trace of old impressions ever reappears on the plate. This remarkable consequence is attributable to a chemical influence, of a particular nature, which the essence exercises upon the coating of silver; and the superiority of the method of Messrs. Belfield and Foucault is attributed to a mechanical action exercised on the metal by the essence of turpentine and other essential oils, which, it seems, have the effect of destroying and completely removing the coating of silver combined with iodine, and producing an entirely new surface.

Another remarkable effect of essence of turpentine is, that plates thus polished

can absorb a much larger quantity of accelerating substance without inconvenience. That upon a plate polished in the old manner, for instance, the least excess of bromine betrays itself by a mist more or less thick, which obscures all or part of the image; with the essence, on the contrary, it would require the excess of bromine to be very considerable to cause a cloud on the impression.

M. Claudet's Process.—The Daguerreotype has had no more zealous follower in this country than M. Claudet, and his system comprehends all that has since been introduced as new improvements under the title of American inventions. The principal aim of M. Claudet has been, in preparing his plates, to dispense with the use of cotton, which leaves a slimy coating on the surface. In order to attain this end he submitted them to three successive operations, namely, the softening or polishing preparation, the separating, and the burnishing processes.

In the first operation, the irregularities the hammering has left on the surface, is to be removed; or, in the case of old plates, fresh silvered with chloride of gold. Every trace of former impressions from the surface, whether fixed or not, is to be removed.

The first polishing requires a turning lathe, on the mandrels of which is mounted a disk of wood, varying in size and thickness according to the size of the plate. This disk is to be first covered with a thick woollen or cotton material, and over this fresh covering a piece of white cotton velvet is tightly stretched; this covering must be without roughness or colour, and it should be boiled for an hour in pure water and then dried. A few drops of olive oil are now poured over the plate, which is then sprinkled over with a little powdered pumice-stone or tripoli powder, carefully prepared, washed, calcined, and dried. The silvered surface of the plate is now applied to the velvet disk, and kept in this position by means of a wooden block supplied with a coating of India-rubber to soften the pressure of the disk. The turning-lathe is now put in motion, and the velvet-covered disk is made gradually to run over the whole surface of the plate. By a series of eccentric strokes the plate is crossed on every side, and in a very short time the surface of the plate will be brought up perfectly even and softened.

The Separation.—The plates have now to be cleared of the coating of oil adhering to its surface, tarnishing its brightness and rendering it incapable of photogenic action. This point is attained by boiling the plate for about half an hour in a saturated solution of carbonate of soda plunging it afterwards in boiling water, and gradually drying it on a piece of clean calico conveniently stretched for the purpose. The plates are now ready to undergo the last polish.

For the third polishing, another disk is prepared and covered with perfectly clean cotton velvet, and mounted on the lathe; over the face of the disk is sprinkled a small quantity of English rouge, applying it to the silvered surface of the plate also, and in a few turns it will acquire a perfectly burnished surface, presenting an intensely black appearance when exposed to the light at a proper angle. All that now remains to be done is to restore the transverse direction of the polish, which should be perpendicular to the intended image. This is done by means of a polishing brush formed of wood, with a handle capable of being held in the hand, and supplied with two or three thick coverings of cloth, and finally with cotton velvet. A few grains of rouge should be sprinkled over, taking this brush in one hand and holding the plate with the ends of the fingers of the other; rub it quickly, but very lightly, till the polish has taken the required direction. Quick and repeated rubbing of the plate immediately before iodizing has the advantage of rendering it quicker, more sensitive and more equal in its distribution.

The operations just described can only be conveniently executed on a large scale, and the process adopted by M. Claudet is modified by each practitioner, according to his own requirements and means, combining it as much as possible with that of Messrs. Belfield and Foucault.

By using essence of lavender for oil, some Daguerreotypists dispense entirely with the second operation of Claudet, having no occasion in this case to clean the plates; the annoyance caused by the grease mixed with oil being avoided.

With their usual mechanical ingenuity, the Americans have added some excellent improvements to the appliances previously in use for polishing plates. We cannot finish this subject more appropriately than by describing some of the best of these; and first let us describe Davie's improved lathe, a recent and decided improvement for polishing plates (Fig. 81).

Fig. 81.

There is no part of the Daguerreotype process requiring more thorough manipulation than that of cleaning and polishing the plate, and none wherein the operator has met with less satisfaction. The hand buff, though good, does not give that finely finished surface so desirable in a good picture; and the lathes commonly used are apt, in some instances, to go to the other extreme, and wear the plate bare of silver. Of the many efforts made to improve the buffing-wheel, none have come so near perfection as the above alluded to.

It occupies but little space, and requires slight exertion. The buffer is a cone of cast iron, twenty-three inches in diameter, neatly covered with wood, and forming a free surface six and a half inches wide. This cone runs in a well-adapted case, which stands firmly on four handsomely turned legs, attached to the box by screws. The cone is turned by a treadle with the left foot. Connected with the machine, are four holders for the different sizes of plates. It is certainly a very neat affair, and will undoubtedly do its work quicker and better than anything of the kind now in use.

Plate Blocks and Vices.—There are several kinds of this article in use; I shall describe the two best only:—

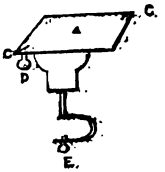


Fig. 82.

Fig. 82 gives an idea of the improvement on the English hand block. The top A is perfectly flat and smooth—a little smaller than the plate, so as to permit the latter to project a very little all round—having at opposite angles C C two clasps, one fixed, the other moveable, but capable of being fastened by the thumb screw D, so as to secure the plate tightly upon the block. This block turns upon a swivel, B, which is attached to the table by the screw C. This block is only used for holding the plate while undergoing the first operation in cleaning.

Fig. 83 shows the form of Lewis's newly patented plate vice, which, for durability,

simplicity, and utility, is preferable to all others. It consists of a simple platform and arm of cast iron, the former A having a groove D in the centre for fixing the different sizes of plate beds, E, and the latter supporting the levers E F. On this vice, which is secured to a table or bench, the plate receives its finishing polish with rouge, or prepared lampblack. Mr. Lewis gives the following directions for its use:—"As the cam wears, tighten it with the adjusting screw, G, so as to allow the lever, F, to fall back into a horizontal position; the plate being in its place at the time. Oil the wearing parts occasionally." For all ordinary purposes, this vice is sufficient; but in larger establishments, where the lathe is necessary, that above described will be found eminently useful.

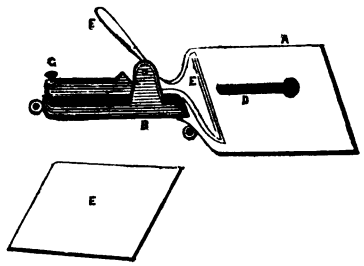


Fig. 83.

Coating Boxes.—The American coating box is also ingenious. The usual form for iodine and bromine boxes is seen at Fig. 84, and consists of a wooden box A, having firmly embedded within it a stout glass jar, the edges of which have been ground. Over this jar is placed the sliding cover B, double the length of the box, one half occupied by a piece of ground glass, E, tightly pressed upon the glass jar by a spring beneath the cross bar G, and which fits the jar so accurately that it effectually prevents the escape of the vapour of the iodine, bromine, or other accelerating liquid contained therein. The other half of the lid is cut through, shoulders being left at the four angles for the different sizes of frames, designed to receive the plate while undergoing the coating process. When the plate is put into the frame, the cover B is shoved under the second lid H, and exposed to the vapour; when coated to the proper degree, it resumes its former position, and the plate is placed in the holder of the camera box. To test the tightness of the box, light a piece of paper, put it into the jar and cover it with the sliding lid. The burning paper expels the air from the jar, and if it be perfectly tight you may raise the whole box by the lid.

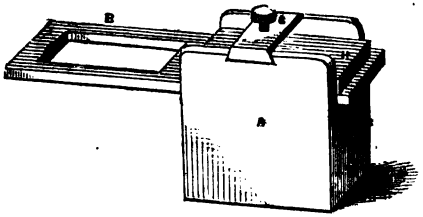


Fig. 84.

Still.—Daguerreotypists should always use distilled water for solutions and washing the plates. For the purpose of distilling water, the apparatus represented at Fig. 85 is both convenient and economical.

It may be either wholly of good stout tin or of sheet iron tinned on the inside, and may be used over a common fire or on a stove. A is the body, which may be made to hold from one to four gallons of water, which is introduced at the opening B, which is then stopped by a cork. The tube D connects the neck F of the still with the worm tub or refrigerator, G, which is kept filled with *cold* water by means of the funnel, and drawn off, as fast as it becomes warm, by the cock F. The distilled water is condensed in the worm, and passes off at the cock G, under which a bottle or other vessel should be placed to receive it. The different joints are rendered tight by luting,

or in its absence some stiff paste, spread upon a piece of linen and wrapped around them, will answer very well; an addition of sealing-wax over all will make them doubly secure.

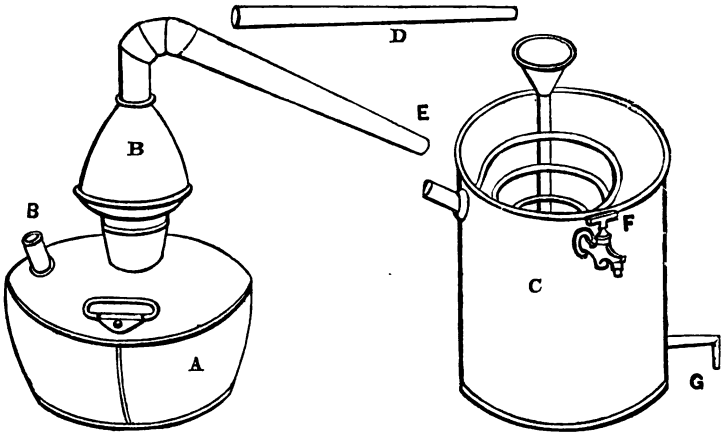


Fig 85.

Preparing Materials.—In whatever manner the materials are to be used, whether by the hand or the lathe, it is essential that they be properly prepared for the purpose. The tripoli requires to be reduced to a perfectly impalpable powder by calcination, and perfectly free from large particles capable of scratching the surface of the plate, and kept for use in a metal or wooden box or bottle contrived for the purpose.

Prepared lampblack is made by burning it to a red heat in a crucible till vapour ceases to arise from it, when the crucible is removed from the fire closely covered up, and suffered to cool. It is then reduced to a fine powder in a mortar, and kept apart in another similar box or bottle.

The rouge requires to be the finest washed that can be procured, and should also be kept in a separate box or bottle. The following mode of using these, as practised in an establishment where a great number of plates are required, is probably as effective as the more elaborate processes described:—"In this establishment there is a lathe, to the head of which can be adapted, by means of the proper screws, a series of circular buffs, the usual number being three. These buffs consist of circular disks of wood, one side of which is covered with a fold or two of unbleached cotton velvet. The buff No. 1 is prepared with olive oil and tripoli; No. 2 with tripoli alone; and No. 3 with lampblack and a small quantity of rouge, or lampblack alone. The plate to be polished is placed in a shallow cavity on the surface of a flat piece of metal, having a projecting tube at its back, and into which is placed a circular iron rod, mounted with a wooden handle, for the purpose of pressing this metal-holder and its contained plate against the circular buff.

The method of proceeding is as follows:—Screw on the buff No. 1, adding, if necessary, some fresh tripoli and oil, and place the lathe-rest about three inches from its surface; the plate is now pressed lightly against the buff, a short distance from its centre, supporting the iron pivot against the rest. The lathe being put in motion by

the foot, causes the plate to revolve very rapidly over the buff, and very quickly removes from it any former picture, scratch, or tarnish. The plate and its holder should now be lightly wiped with a portion of cotton wool, to remove as much as possible of the superfluous oil, &c. The buff No. 2 is now to be substituted for the oil buff, and the plate again applied in the way just described, till all appearance of oil is removed, and the plate appears equally polished. The plate is now laid, silver side upwards, on a stand, similar to the one here represented (Fig. 86), and the flame of a spirit lamp applied underneath till a slight smoke appears to rise from it, and its surface assumes a slight white tint; by this process the remaining traces of oil are burnt away, and the plate is ready to receive its final polish by means of the buff No. 3.

Fig. 86.

When the plate is properly polished, its surface should look quite black and free from scratches when viewed in a particular light. If this is not the case, it must be applied some time longer to the buff No. 3 till that result is produced.

The other method of polishing where a lathe cannot be obtained, or would not be admissible on account of its cumbrous nature, consists in employing a series of cotton-velvet buffs, varying in size from three inches by twelve inches to nine inches by eighteen, according to the size of the plates. The least number required is four; the first buff is prepared with tripoli and oil, the second and third with tripoli alone, and the fourth with prepared lampblack and a very small quantity of rouge; they must be kept separate from each other, and each carefully reserved for its own particular use. The method of proceeding is to lay the plate face downwards, upon the oil buff No. 1, and then, by means of a similar plateholder to that employed for the lathe, or else one made of wood of the form represented in Fig. 87, the plane surface of which is rendered adhesive by some prepared India-rubber, the plate is briskly moved over its surface with a very slight pressure for the space of a minute or so; it is then cleared from adhering oil, &c., with some cotton wool, and rubbed lightly first on No. 2 buff, and afterwards on No. 3, adding some fresh dry tripoli as required. The plate is now heated with a spirit-lamp, as before described, and finished on the buff No. 4.

Fig. 87.

If the plate to be polished be very free from scratches, and has not been subjected to the setting process with salt of gold, the use of the oil buff may be dispensed with, and those prepared with tripoli and lampblack alone used.

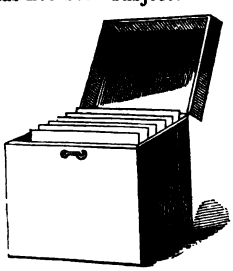


Fig. 88.

The following are the most important precautions to be observed to insure the proper result in the foregoing processes. The buffs and polishing materials should be carefully preserved from dust, dirt, and damp; the former of these is easily accomplished by keeping each separate buff in its own case, which may be made either of wood or parchment, and the latter by keeping them in some dry place. If there should be any doubt relative to the buffs being perfectly dry, it will be advisable to place them, well protected from dust, before a fire, a short time previous to using.

When the plate is polished by either of the processes described it may be protected

from injury in a wooden or metal box, similar to the one represented in Fig. 88. When the plate is about to be used, it should receive a final polish, and have its grain laid in a particular direction, by means of a buff, either covered with cotton velvet, or a piece of smooth, soft doeskin, of the shape here represented (Fig. 89).

The plate, if a small one, can be supported on the ends of the fingers of the left hand, using the buff with the right; if the plate be too large or thin to be supported on the fingers, any convenient form of plateholder can be employed, taking care that it is perfectly free from dust or grease. The buff should be briskly rubbed over the plate with a slight degree of pressure for a few seconds, or till all the fine lines on the surface of the plate appear in one uniform direction, bearing in mind that for portraits the lines should not be in the direction of the face, but across it; and for views, in the direction of the view. The plate is now ready, and should immediately be subjected to the next operation, which is—

Fig. 89.

Applying the Sensitive Coating.—The simplest form of apparatus necessary for this purpose consists of two porcelain or glass pans, ground on the edges and furnished with plate-glass covers, and a series of wooden or metal frames of the size of the plate to be prepared; one of these pans is for holding the iodine, and the other the accelerating material. The plate to be prepared is placed in its proper frame, and substituted for the plate-glass cover of either pan, as may be required; the progress of the preparation being observed from time to time by the tint of colour produced on the plate when removed for an instant, and viewed at such an angle that the light transmitted through a sheet of white paper held before the plate may be reflected to the eye. When the proper colour is obtained, the plate is exposed for an instant or two longer, to remove any effect of the light, and then rapidly placed in the camera frame; the glass cover is now replaced.

In consequence of being obliged to remove the cover of these pans to observe the colour of the plate, the vapour of iodine, &c., within the pan becomes disturbed, and rarely produces an even coating; this is avoided by using the glass pans of greater depth, and mounted as shown in Fig. 90.

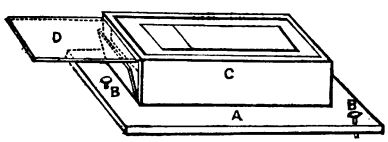


Fig. 90.

The plate to be prepared is placed in the proper opening at the top of the box, and on removing the glass sliding-cover and replacing it again before the plate is removed, a much better result is obtained.

The only form of apparatus that can be relied upon for producing a uniform good result is that shown in Fig. 91, or one constructed on similar principles. It is technically termed a bromine apparatus, and consists of two deep glass pans with polished sides, and mounted in a wooden box, at the back of which are two openings, corresponding to the two pans, over which is fastened a piece of white paper. In the front of the box, and immediately opposite the back openings, are two small doors opening

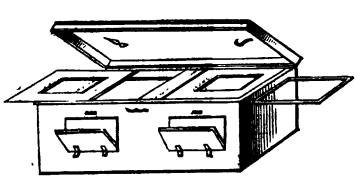


Fig. 91.

outwards, and each lined with a piece of looking-glass. Two glass covers, and a series of wooden frames sliding over them on the top of the box, complete the apparatus. From half to one ounce of pure crystallized iodine is placed at the bottom of one of the pans and the accelerating material in the other, and they are then closed with their respective covers, and the whole apparatus placed before a window with a moderate light. The accelerating material which I have uniformly found produce the best and most certain results is a chloride of bromine, made by mixing one ounce of a saturated solution of bromine with one drachm of strong hydrochloric acid. This preparation must be kept in a-stopped phial. Water is poured into the glass pan of the bromine apparatus to the depth of about half an inch, and sufficient of the chloride of bromine added to bring the whole to the colour of very pale sherry.

The plate to be rendered sensitive to light is placed in its required frame at the top of the bromine apparatus, and immediately over the pan containing the iodine; the plate-glass cover is then removed so as to expose the plate to the vapour of the iodine below; the small mirror is now so adjusted that, by looking into it, the white paper at the back can be seen reflected from the surface of the silver plate, and any change of colour immediately perceived. When the plate has assumed a light straw colour, the cover is to be returned over the iodine, and the slide holding the plate shifted over the pan containing the chloride of bromine; the cover is now to be withdrawn, the mirror adjusted as for the iodine; and the glass cover being removed, the plate is exposed to the vapour till it becomes of a deep yellow colour, when it is returned over the iodine till of a rose tint, and immediately placed in the camera frame. The dilute solution of chloride of bromine will serve to prepare a considerable number of plates; and when it fails to produce its effect, it will always be found the better plan to mix a fresh quantity rather than increasing its strength by the addition of more of the strong solution.

There are a great many preparations of bromine known by the names of eau bromée, bromide of iodine, Hungarian solution, Woolcott's American accelerator, bromide of lime, &c., which are employed by some operators with much success.

When the bromide of iodine, or Hungarian solution, is employed, it should be diluted with four or five times its bulk of water, and the plate, previously iodized to a deep yellow, exposed to it till a deep rose or violet colour. Woolcott's accelerator and bromide of lime both require the same tints as the chloride of bromine before described. The bromide of lime, chloro-bromide of lime, and other dry accelerators of that character, are used in the bromine apparatus, spread evenly over the bottom of one of the pans to the depth of about a quarter of an inch.

Should the plate by accident be left too long over the iodine in the first preparation, and show some indications of a rose tint, it must be brought to a full rose over the accelerator, and then to a blue over the iodine; this will often produce a good result, and save the trouble of re-polishing the plate.

The plate, after being prepared by one or other of the foregoing processes, must be returned to the dark box or camera back till required for the next process, viz.:—

Exposure in the Camera.—The mode in which this is effected must, of course, depend upon the construction of the camera, whether it have a lens, as originally proposed by Daguerre, or a concave mirror or speculum, which is the apparatus patented in this country by Mr. Beard. Both kinds have their advantages. The refracting camera, as recently improved, appears to possess all the capabilities without many of those inconveniences which attend on the manipulation with the

reflecting camera, and being withal less expensive, is now the form generally used.

The first thing to be attended to, before introducing the plate, is to place the camera on some firm support, and opposite to the object wished to be copied; after which the focus should be adjusted with the greatest care till a perfectly clear and distinct image of the object is seen on the piece of ground-glass, which should be placed in exactly the same position as the plate is to occupy, taking especial care that the ground side of the glass should correspond to the prepared surface of the plate. When the focus is obtained, the light should be shut off by a brass cap, or other contrivance for that purpose, till the plate is introduced, or the camera may be taken into a dark room, and have the plate put into its place, when it can be brought into the light, having, of course, made those obvious arrangements, that the object and the camera be placed in precisely the same relative positions they occupied when the focus was adjusted.

The camera may then be opened to allow the light to fall on the plate through the lens. The time requisite for it to remain open will depend, in a great measure, upon the season of the year, time of the day, and the brightness or clearness of the atmosphere. The time usually required with a good achromatic and a well-constructed camera varies from one to sixty seconds.

When the camera has been opened a sufficient time, which can only be determined by observation and experiment, close the front aperture, and take it into a dark room, when the picture, which is impressed on the sensitive surface of the plate, is to be made visible by being exposed to the fumes of mercury.

Mercurializing the Plate.—The apparatus required for this operation is called a mercury box, and is shown in the accompanying cut:—

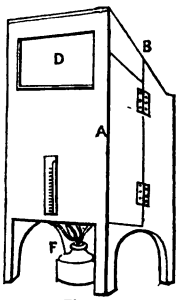


Fig. 92.

The body, A, is made of wood, and has an iron cup, fixed in the bottom, for holding the mercury, which is heated by a spirit lamp, F; the upper part of the box, A, is grooved, so as to receive the same sliding frame, B, that fits the back of the camera and holds the prepared plate, or else the prepared plate alone; at the front of the box is a small yellow glass window, C, over which slides a shutter, D. When about to be used, pour a small quantity of pure mercury (four to six ounces) into the metal cup at the bottom of the box; the mercury should then be heated by means of a spirit lamp, till the outside of the metal cup can be touched with the finger without much inconvenience. The plate may then be taken from the camera and placed in the mercury a short time, by cautiously applying a lighted taper to the side, and looking through the glass in front, the development of the picture can easily be perceived.

If the mercury be made very hot, the picture soon makes its appearance; but, generally speaking, when done too rapidly, the minor details are lost and the plate is apt to become spotty; it is always advisable, where time is not a great object, to do the operation rather slowly than otherwise, as a much clearer and sharper outline of the picture will be obtained by this means than if done rapidly. The usual time required is from five to twenty minutes.

If the mercury box be furnished with a thermometer, which is sometimes the case, the temperature may be kept about 90 degrees.

The mercury should be perfectly dry and free from any particle of oxide, and should

be poured into a bottle after each series of experiments. When it loses its brilliancy, it may be purified by filtering through a paper cone, having a very fine opening at the bottom. The mercury box ought also to be carefully dusted out before using.

When the picture has become sufficiently distinct, it should be removed from the mercury box and subjected to the next operation, viz.:—

Removing the Sensitive Coating.—The solution required for this is made by dissolving two ounces of hyposulphate of soda in one pint of water; this solution will serve many times, if it be filtered before using. The solution is placed in some convenient shallow vessel, and the plate quickly immersed in it; the colour will be observed to gradually disappear, and when that is the case it should be placed in a vessel of filtered water, to remove the excess of hyposulphite, and subsequently a small quantity of distilled water poured over its surface.

Fixing the Picture.—The solution of gold which is required for this process is prepared by dissolving 15 gr. of chloride of gold in one pint of water, and adding it little by little, to a mixture of 60 gr. of hyposulphite of soda and eight ounces of water, the whole being well agitated between each addition. The solution, at first slightly yellow, becomes afterwards perfectly limpid. Before the surface of the plate becomes dry, it is to be placed, face upwards, upon the fixing stand, which is so constructed as to preserve it in a perfectly horizontal position by means of levelling screws, and the solution of gold being poured over its surface, until it is perfectly covered, and the flame of a large spirit lamp applied to the under surface, moving it gently beckwards and forwards, that every part may be equally heated, the picture will be seen to brighten, and become in a minute or two of great force. When this effect is produced, the liquid should be thrown off, and the plate instantly dipped into water, washed, and dried. If the plate be a large one, it is most conveniently dried by placing it on a smooth and clean piece of copper or tin plate, and some boiling distilled water poured over its surface, at the same time inclining the plate so that the water may run off from one of its lower corners, and it will in a very short time become perfectly dry.

If the plate be of a small size, it can be conveniently dried over a spirit lamp. It should be held by means of a small pair of pliers, by one of its corners, and some filtered distilled water poured over its surface; by inclining the corner held by the pliers, the greater portion of the liquid will flow to that part, and can be removed by touching it with a piece of rag or blotting-paper; the spirit lamp may then be applied to the upper corner of the plate till it begins to dry, and the flame gradually brought lower down, till the whole surface is finished. Gently blowing downwards on the plate will expedite the process, as well as prevent, in a great measure, the formation of spots.

It sometimes happens that, while the plate is being heated with the solution of gold, a film of silver detaches itself and swims in the liquid, of course destroying part of the picture. This accident is probably owing to the oxidation of the silver while under the influence of too much heat.

The lamp should be removed as soon as the small bubbles of air appear to form on the surface of the metal. When the picture is not perfectly fixed, it is better to make a second trial, rather than run the risk of spoiling a good picture by trying to fix it perfectly the first time.

Colouring Daguerreotypes.—As the objects copied by the Daguerreotype process are only represented in light and shade, not in the colours as they appear in nature, it has been suggested, after the picture has been set, to colour them by hand, similar to a painting; and certainly, when done in an artistic skilful manner, it produces a very pleasing

effect. The simplest method is to use dry colours, ground extremely fine, with some dry gum or starch. The picture must be well set with gold, and the colour applied or dusted on with a fine camel's-hair pencil, taking up a very small quantity of colour at a time, removing the superfluous colour by blowing it off with a caoutchouc bottle; when the desired tint is produced, breathing on the plate will cause the colour to adhere. M. Claudet's method is to mix a small quantity of the colour with spirit of wine, applying it to the plate with a camel's-hair pencil, and if not sufficiently dark, some of the dry colour is applied over it, to which it will adhere. As a general rule, the colours should be applied very cautiously, as it is very difficult to remove them when once on the plate. The best colours to be used are carmine, chrome yellow, and ultra-marine, by combining which any desired tint may be obtained.

Daguerre's Improvements.—The Daguerreotype process is, as we have seen, much more complicated in its manipulation, and less satisfactory in its results than either the collodion, wax-paper, or calotype. The preparation of the plates is a mechanical operation, requiring great delicacy in handling, and the application of the sensitising vapours are processes requiring great care and considerable knowledge of chemical manipulation. The uncertainty of the results, even of the best operators, led M. Daguerre, to return to the subject for the purpose of reviewing his process, which he does in the "Comptes Rendus," of March, 1842. The uncertainty he attributes to two principal causes; first the defective operation of polishing, in consequence of the impossibility of entirely divesting the surface of traces of the liquid, cotton, and other substances, used in the operation, which prevents the iodine from coming into direct contact with the silver, and consequently retards the photogenic action. And, second, in the alterations in the temperature of the air with which the plate is in contact, from the earliest operations to the mercurial bath, in consequence of the colder body of the metal condensing moisture from the surrounding air.

The following process recommended is very simple, and obviates both the inconveniences above mentioned; it frees the silver as much as possible from all dirt or dust, and neutralizes the humidity produced by the elevation of temperature in the mercurial box.

The process consists in covering the plate, after having polished it, with a layer of very pure water, and heating it very strongly over a spirit lamp, pouring off the first layer of water in such a manner that the dust which has been raised, floats away without touching the plate.

It is necessary, in order to accomplish this, to have a frame of iron wire, of the size of the plate, at one of its angles having a handle, and in the middle, on the two opposite sides, two small cramp-irons, to retain the plate when it is inclined. After having placed this frame on a horizontal plane, the plate is placed on it, and is again covered with a layer of very pure water, putting as much as the surface can retain. The bottom of the plate is afterwards very strongly heated, and very small bubbles are formed at the surface. By degrees these bubbles become larger, and finally disappear; the heat must be continued to ebullition, and then the water must be poured off. The operator should commence by placing the lamp under the angle of the frame where the handle is; but before removing the frame, this angle must be very powerfully heated, and then, by gradually moving it by its handle, the water immediately begins to run off. It must be done in such a way that the lamp shall follow, under the plate, the sheet of water in its progress, and it must be only gradually inclined, and just sufficient for the layer of water, in retiring, not to lose in thick-

ness; for if the water were dried up, there would remain small isolated drops, which, not being able to flow off, would leave on the silver the dust which they contain. After that, the plate must not be rubbed; very pure water does not destroy its polish.

This operation should be performed just before iodizing the plate. Whilst it is yet warm, it is placed in the iodizing box, and, without allowing it to cool, it is submitted to the vapour of the accelerating substances. Plates thus prepared may be kept one or two days (although the sensibility diminishes a little), provided that several plates be placed opposite to one another, at a very short distance apart, and carefully enveloped to prevent change of air between the plates.

It is one of the most important points to obtain a fine polish on the plate, but the brilliancy often disappears when substances which adhere to the surface of the silver are used, such as the peroxide of iron, which has been very generally made use of for giving the last polish. This substance, indeed, seems to burnish the silver, and to give it a more perfect polish; but this polish is factitious, since it is not really in contact on the silver, but is, in fact, on a very fine layer of oxide of iron. It is for this reason that there is required for polishing them a substance which does not adhere to the silver; pumice leaves less residue than any other substance.

As regards the liquid to be employed: in the first operations nitric acid of five degrees must be employed, but for the last operations it must be reduced to one degree. The polishing with oil and the heating may be suppressed.

The layer produced by the descending vapours of the iodine and of the accelerating substance forms with silver a more sensible compound than is obtained with the ascending vapours. I make this observation only to lay down a fact, for it would be difficult to employ descending vapours, on account of the dust which might fall during the operation, and from stains.

The resistance which light experiences in passing through a white glass is well known. This resistance is even greater than it appears, and may be attributed not only to the dust which is left on the glazing in cleaning it, but also to that which is naturally deposited on it. The object-glass of the camera obscura is certainly in the same case. To ascertain this, I put the object-glass in cold water, which I boiled; I knew that it was impossible to remove it without the sides. This operation had, therefore, no other object than to raise the temperature of the glass to 212° F. C., and I then immediately poured on the two sides of the object-glass very pure boiling water to remove the dust. By operating directly with the object-glass, thus cleansed, I still further increased the promptitude. This means presents too many difficulties to be put in practice; only care should be taken to clean the object-glass every day.

The atmospheric dust, which is the scourge of photogenic images, is, on the contrary, favourable to images which are obtained by contact or at a very short distance. To be convinced of this, we have only to clean the two bodies which we wish to put in contact with the boiling water, as I have just indicated, and to keep them both at the same temperature as the air; there will then be no impression, which evidently proves that these images have no relation with the radiation which gives photographic images.

M. Fizeau's Preparation.—The preparation of bromine water is thus described by M. Fizeau:—"To prepare a solution of bromine, of a fixed proportion and convenient strength to operate with, I, in the first place, make a saturated solution of bromine in water; this is prepared by putting into a bottle of pure water a great excess of bromine, agitating strongly for some minutes, and before using allowing the bromine to separate. Now, a

definite quantity of this saturated water is to be mixed with a definite quantity of plain water, which will give a solution of bromine always in the same strength: this mixture is conveniently made in the following manner:—The apparatus necessary is a *dropping tube*, which is also required for another part of the process, capable of holding a small definite quantity, and a bottle having a mark to indicate a capacity equal to thirty times that of the dropping tube: fill the bottle with pure water to the mark, then add, by means of the dropping tube, the proper quantity of the saturated solution of bromine.

"The purity of the water is of some importance: the foregoing proportions refer to the pure distilled water, and it is well known that the waters of rivers and springs is not pure; but these different varieties can be used as absolutely pure water by adding a few drops of nitric acid till they taste slightly acid; two or three drops to the pint is generally sufficient.

"The liquid produced, which is of a bright yellow colour, ought to be kept in a well-stoppered bottle; it is the normal solution, and I shall call it simply bromine water, to distinguish it from the saturated solution.

"The box I employ for subjecting the plate to the vapour of the bromine water is constructed in the following manner:—It consists of a box lined with a varnish, which is not acted on by bromine; its height is about four inches; the other dimensions are regulated by the size of the plate, which ought to be at least half an inch all round, short of the sides of the box; it is composed of three separate portions—the cover, which is the frame holding the plate, the body of the box, and the bottom, upon which is placed the vessel for the bromine; this moveable bottom is slightly hollowed, so that the bromine vessel may always be placed in exactly the same position."

Bromide of iodine is prepared by M. Valicour's method thus:—Into a bottle of the capacity of two ounces, pour thirty or forty drops of bromine, the precise quantity not being of importance. Then add, grain by grain, as much iodine as the bromine will dissolve till quite saturated. This point may be ascertained by some of the iodine remaining undissolved. In this state it is too concentrated for use; but by dropping fifteen or twenty drops into half an ounce of distilled or filtered rain-water, the requisite strength may be obtained.

Mr. R. J. Bingham, in an article published in the "Philosophical Magazine," October, 1846, gives an improvement in the Daguerreotype process by the application of some new compounds of bromine, chlorine, and iodine. "In warm weather," he remarks, "a considerable deposition of moisture takes place upon the glass or slate cover used to confine the vapour in the bromine or accelerating pan. This moisture must also necessarily condense upon the cold metallic surface of the plate during the time it is exposed to the bromine vapour. In fact, it is difficult to obtain perfect pictures during the excessive heat of the late season. This appears to be owing to the deposition of moisture upon the plate, arising from the water in which the bromine is dissolved. To obviate this, some have recommended the pan to be kept at a low temperature in a freezing mixture; and M. Daguerre, in a communication to the French Academy of Sciences, recommends the plate to be heated: but in practice both these are found to be unsuccessful.

"It appeared to me, that if we could avoid the use of water altogether in the accelerating mixture, not only would the difficulty I have mentioned be avoided, but a much more sensitive surface would be obtained on the plate. With this view, I endeavoured to combine bromine with lime, so as to form a componnd analogous to bleaching powder. In this I was successful, and find that bromine, chloride of iodine,

and iodine, may be united with lime, forming compounds having properties similar to the so-called chloride of lime.

"The bromide of lime may be produced by allowing bromine vapour to act upon hydrate of lime for some hours. The most convenient method of doing this is to place some of the hydrate at the bottom of a flask, and then put some bromine into a glass capsule supported a little above the lime. As heat is developed during the combination, it is better to place the lower part of the flask in water at the temperature of about 50° Fah.: the lime gradually assumes a beautiful scarlet colour, and acquires an appearance very similar to that of the red iodide of mercury. The chloro-iodide of lime may be formed in the same manner—it has a deep brown colour. Both these compounds, when the vapour arising from them is not too intense, have an odour analogous to that of bleaching powder, and quite distinguishable from chlorine, bromine, or iodine alone.

"Those Daguerreotypists who use chlorine in combination with bromine, as in Woolcott's American mixture, or M. Guerin's Hungarian solution, which is a compound of bromine, chlorine, and iodine, may obtain similar substances in the solid state, which may be used with great advantage. By passing chlorine over bromine, and condensing the vapours into a liquid, and then allowing the vapour of this to act upon lime, a solid may be obtained, having all the properties of the American accelerator; or by combining the chloro-iodide of lime with a little of the bromide, a mixture similar to that of M. Guerin's may be produced: but I greatly prefer, and would recommend, the pure bromide of lime, it being, as I believe, the quickest accelerating substance at present known. By slightly colouring the plate with the chloro-iodide, and then exposing it for a proper time over the bromide, proofs may be obtained in a fraction of a second, even late in the afternoon. A yellow colour should be given by the use of the first substance; and the proper time over the bromide is readily obtained by one or two trials. With about a drachm of the substance in a shallow pan, I give the plate ten seconds the whole of the first day of using the preparation, and add about three seconds for every succeeding one. The compound should be evenly strewed over the bottom of the pan, and will last, with care, about a fortnight.

"The great advantage of this compound is, that it may be used continuously for a fortnight without renewal; and, unlike bromine water, its action is unaffected by the ordinary changes of temperature."

M. Fizeau, who has carefully studied this branch of the science, gives the following directions for giving greater permanence to the Daguerreotype picture:—

"Dissolve eight grains of chloride of gold in sixteen ounces of water, and thirty-two grains of hyposulphite of soda in four ounces of water: pour the solution of gold into that of the soda, a little by little, agitating between each addition. The mixture, at first slightly yellow, becomes perfectly limpid. This liquid now contains a double hyposulphite of soda and gold.

"To use this salt of gold, the surface of the plate should be perfectly free from any foreign substance, especially dust; consequently it ought to be washed with some precaution, which might be neglected if it was to be finished by the ordinary mode of washing,

"The following manner generally succeeds the best:—The plate being yet iodized. and perfectly free from grease on its two surfaces and sides, should have some drops of alcohol poured on the iodized surface; when the alcohol has wetted all the surface, plunge the plate into a basin of water, and after that into a solution of hyposulphite of soda.

"This solution ought to be changed for each experiment, and to consist of about

one part of the salt to fifteen of the water; the rest of the washing is done in the ordinary way, only taking care that the water should be as free as possible from dust.

"The use of the alcohol is simply to make the water adhere perfectly all over the surface of the plate, and prevent it from quitting the sides at each separate immersion, which would infallibly produce stains.

"When a picture has been washed, with these precautions, the treatment with the salt of gold is very simple. It is sufficient to place the plate on a support, and pour upon its surface a sufficient quantity of the salt of gold, that it may be entirely covered, and heat it with a strong spirit-lamp; the picture will be seen to brighten, and become, in a minute or two, of great force. When this effect is produced, the liquid should be poured off, and the plate washed and dried.

"In this operation the silver is dissolved, and the gold precipitated upon the silver and mercury, but with very different results; in effect, the silver, which, by its reflection, forms the shades of the picture, is in some way darkened by the thin film of gold which covers it, from which results a strengthening of all the dark parts. The mercury, on the contrary, which, in the state of an infinite number of small globules, forms the lights, is augmented in its solidity and brightness by its union with the gold, from which results a great degree of permanency, and a remarkable increase in the lights of the picture."

STEREOSCOPIC PHOTOGRAPHY.

Binocular Vision.—There is scarcely anything more interesting in the study of optics than the theory of binocular vision. Few persons are aware of the fact, that without two eyes it is impossible to form a *correct* judgment of distances; this may, at first sight, appear strange, but the *fact* may be proved beyond a doubt. Previously to my proceeding to do so, I shall mention a few cases to the point. A gentleman, a friend of mine, lost the sight of one of his eyes some couple of years ago, and to this day he cannot measure distances—for instance, it sorely puzzles him to snuff a candle, to dip his pen in an ink-bottle, to take hold of anything a little distance from him, &c., &c.; and it is a curious *fact* that he, and others like him, are nearly always *short* of the object. I knew a lady, who had met with the same misfortune, and have often been amused at seeing her try to pour wine out of a bottle into a decanter, or threading a needle. To descend a little lower in the scale of creation, I had a young cat at one time who lost the sight of one *eye*, and the mistakes she used to make in playing with a ball were truly laughable. For instance, when the ball would roll away for a few feet, she would make a bound, but could never get within three or four inches of it, and if she made a jump to get on a wall, &c., she invariably fell *short*. These are but a few of the numerous instances that I could mention, but they are enough to introduce the subject. And now for some of the proofs.

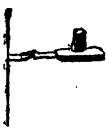


Fig. 92.

Experiment 1st.—Insert the prongs of a fork into a door or wall, about three feet six inches, or four feet from the floor, and on the handle or haft of the fork place a cork upright (Fig. 92). Now provide yourself with a cane, or thin walking-stick, go to the other end of the room, and, shutting one eye, walk briskly up towards the cork, and raising the cane at the moment strike at the cork without any *stop* or *hesitation*, keeping *one eye shut all the time*, the chances are that you will not hit the cork once out of six times.

Experiment 2nd.—Procure a small piece of pipe-stem, and insert it in the cork of a bottle (Fig. 93). Then stand away from the bottle, about eighteen inches or two feet, and, taking a pointed pencil in your fingers *shut one eye*, and try to place the point of the pencil on the top of the piece of pipe-stem. You may take what time you please to calculate the distance, providing you keep the *one eye shut all the time*, and that you do *not repeat the experiment without withdrawing the hand each time*, the chances are that you will not do it *once in twelve times*. The pipe and pencil appear as in Fig. 94 to the single eye, being a front view; but to any person looking at them from the side they would appear as in Fig. 95 or Fig. 96, but more generally the former.

Fig. 93.

Fig. 94.

Experiment 3rd.—This is by far the most conclusive experiment of the three. Instead of a pipe-stem, procure the end of a quill, or the round end of a *magnum bonum* steel pen, which insert in the cork as in Fig. 97, and, *shutting one eye*, endeavour to drop into the open end of the pen or quill a grain of shot: you may hold the shot within an inch of the pen before you drop it. The chances are you will not drop it in *once in twenty times*. These few simple experiments go far to prove the almost impossibility of calculating distances correctly with one eye.

Fig. 95.

Fig. 96.

Fig. 97.

The next subject for consideration is, in what manner are we able to calculate distances by using two eyes.

This subject will be more fully explained by the following experiments:—

Experiment 4th.—Stand a book on its edge as in Fig. 98, and so place it that, having the right eye only open, you can see nothing but the back. Shut the right eye and open the left, when the book will appear as in Fig. 99. Of course the same effect would be produced on the other side by using the left eye in the first instance; but if the book be placed exactly between the eyes, then it will appear as in Fig. 100; but not immediately; for as the rays from the eyes can only meet at one point from the latter *at the same time*, or, as it may be considered, the eyes can only *focus* at one point at once, the back of the book appears correctly defined, and the right or left eye sees its own side, *which ever predominates*. It may not be generally known that most persons only use one eye to take in an object or figure, the other being only used to check or determine the distance or relative size of that object, as in the case of focussing in the camera, when you obtain the object perfectly sharp and distinct; then, without altering the eyes or their point of sight, open and shut *one alternately*, and you will at once perceive that *only one eye sees the image properly*. This arises from the fact, that the ray or pencil of light coming through the lens cannot be by any possibility reflected on different points at once. We therefore can see *only one object* at any distance at any one time, although we may be perfectly conscious of other objects nearer or further away. To bear out both these assertions, it will perhaps be necessary to try the following simple experiment:—

Fig. 98.

Fig. 99.

Fig. 100

Experiment 5th.—Place a small mirror at about two feet six inches from you, and so arranged that it may take in a picture which will about half fill it, and be about eight or nine feet in your rear. This will appear to be exactly in the centre of the mirror, as in Fig. 101. Now, although we are looking at the picture, we are also conscious that the looking-glass is there, and that we can see the frame. Having satisfied ourselves of this, we next proceed to prove that one eye sees more than the other. For instance, shut the right eye—still looking at the picture—and if we see more with the left than the right, the picture will remain in its original position; but if we habitually see more with the right than with the left, then the picture will immediately change over, so to speak, and appear as in Fig. 101. This fact proves, in the first instance, that we cannot see more than one object at once; for although we were conscious of the existence of the frame of the mirror, we could not see it distinctly. And it proves, secondly, that we see more with one eye than the other, or the picture would not change its position in the mirror by shutting or opening the eyes; and thus we have A (Fig. 103), the left eye, and what it sees; B, the right eye, and what it sees; C being the picture.

Fig. 101.

Fig. 102.

It must be recollected, that the picture being apparently so far behind the mirror, the latter only intersects the rays proceeding to the eyes, as if it were a plain piece of glass *through* which we were looking at the picture (Fig. 104).

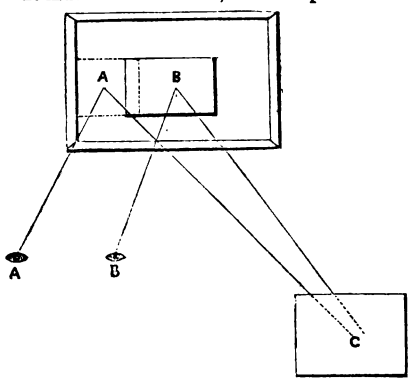


Fig. 103.

The fact of the rays from the eyes meeting, or being *focussed* on an object at a certian distance, and only *on that object at the time*, may be further proved by the following experiments:—

Experiment 6th.—Place a lighted candle about two feet from you, and hold a pencil half the distance between, and in the centre of the eyes (Fig. 105). Now keep all steady and look at C (the pencil) and you will see two candles, one on each side; then look at the candle and you will see two pencils, one on each side. In the former case the pencil will be lighted on each side; and in the latter case the two pencils will be lighted on the inside of each.

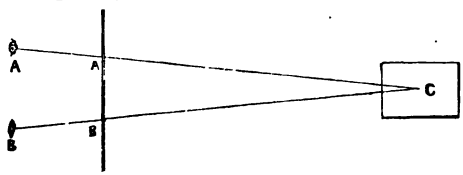


Fig. 104.

The following diagrams will explain this more fully. When looking at the pencil we see, by opening and shutting each eye alternately, the object looked at distinctly, and the other indistinctly, but still we see it; therefore, when looking at the

pencil with the left eye, or A, we see it and the candle as in Fig. 106, and with the right eye as in Fig. 107.

At first, from looking at these diagrams, one would think that we saw the pencil at C when looking with both eyes; and were also conscious of one candle at D, as Fig. 107 would lead us to suppose. Here we see Figs. 106 and 107 united (Fig. 108), and would naturally imagine that we would only see one candle and one pencil; but the reverse is the fact, for as one eye is not able to judge of distance, and both are focussed on the pencil at C, they are each conscious of a candle behind C, and naturally bringing the second object into the plane of focus, or nearly so (Figs. 109, 110).

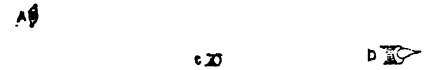


Fig. 105.

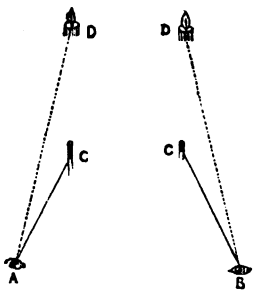


Fig. 106.

Fig. 107.

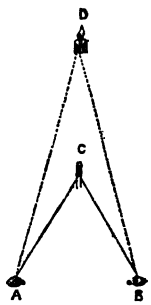


Fig. 108.

The same result occurs in a reverse way when we look at the candle instead of the pencil; but, in this case, the rays cross each other, throwing the pencil back apparently with the candle. But, in the latter case, the left eye, or A, sees the candle and pencil as in Fig. 111; and the right eye, or B, as in Fig. 112.

In all the preceding diagrams, the solid lines represent the line of sight, and the dotted ones the line of light of the figure of the presence of which we are conscious.

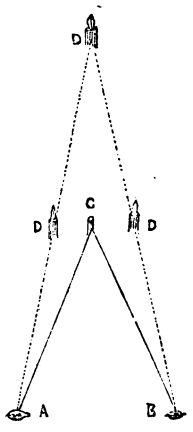


Fig. 109.

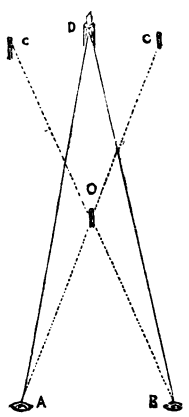


Fig. 110.

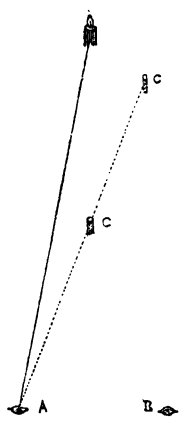


Fig. 111.

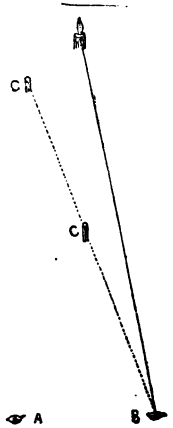


Fig. 112.

The foregoing facts will prove, satisfactorily I hope, that without two eyes we

cannot form a correct judgment of distance, and in the same manner of size, form, &c. The next subject will therefore be, how do we take advantage of this fact in photography? We do it simply thus: We consider that a picture or portrait taken by *one* lens and *one* camera is exactly in the position of a similar one looked at by *one* eye; and, to obtain the manifest advantages derived from the use of two eyes, we either employ two cameras and two lenses at certain angles apart, or we take the same view or portrait twice, each taken from a different angle. The former method, for many reasons, is decidedly to be preferred.

The pair of stereoscopic pictures will convey to the mind of the observer (*by means of a properly constructed instrument*) all the effects obtained by the use of two eyes; that is to say, the picture which nature would present to the left eye is seen by the left eye, and that to the right by the right. We therefore observe, when viewing a stereoscopic picture in a stereoscope, that the figures, houses, trees, &c., are perfectly correct as to size, natural position, and relative distance from each other. This fact is so well known, and truly wonderful, that it need not be repeated.

The next subject for consideration will be—

The Stereoscope.—The almost magical effect of two plain flat pictures viewed in the stereoscope is so vivid, when seen for the first time, that the result seems to be a deception of the imagination; in fact, we are inclined to remove the stereoscope and see for ourselves, somewhat like the Indian who went to look behind the looking-glass for the image he saw reflected on its surface. And even when we become accustomed to the use of the instrument we always take a pleasure in looking at the views we may have often seen before; in fact, every object seems to stand out with all the solidity of nature; and in some cases, where the calotype has been properly coloured, the effect, especially in portraiture, is perfectly marvellous.

In the stereoscope, then, we have the most interesting optical instrument ever discovered, reproducing, as it were, in all the reality of nature, the favourite scenes of youth or the semblance of some beloved friend who is gone, perhaps, alas! for ever.

The most simple, most portable, and, I may say, the most correct in principle, is that invented by Sir David Brewster.

This instrument consists of two semi-lenses, placed at such a distance that each eye views the picture or drawing opposite to it, through the margin of the semi-lens, or through parts of it equi-distant from the margin (Fig. 113). A lens, A A′, being cut in two halves, these are fixed into a frame, L and L, and adjusted to such distances that the centres of the semi-lenses correspond with the pupil of the eyes. The distance of the centre of one pupil from the other is at an average of two inches and a half, and to this the semi-lenses may be adjusted; but if the instrument is provided with the means of effecting a little change in this respect, it will often be found to be of considerable advantage.

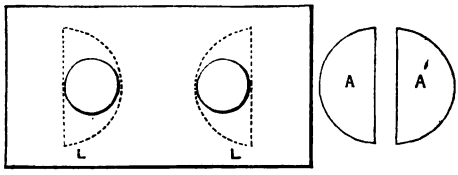


Fig. 113.

Sir David Brewster says, "When we thus view two dissimilar drawings of a solid object, as it is seen by each eye separately, we are actually looking through two prisms, which produce a second image of each drawing; and when these second images unite, or coalesce, we see the solid image which they represent. But in order that the two

images may coalesce, without any effort or strain on the part of the eye, it is necessary that the distance of the similar parts of the two drawings be equal to *twice* the separation produced by the prism. For this purpose measure the distance at which the semi-lenses give the most distinct view of the drawings; and having ascertained, by using one eye, the amount of the refraction produced at that distance, or the quantity by which the image of one of the drawings is displaced, place the drawings at a distance equal to twice that quantity; that is, place the drawings so that the average distance of similar parts in each is equal to twice that quantity. If this is not correctly done, the eye of the observer will correct the error by making the images coalesce without being sensible that it is making any such effort. When the dissimilar drawings are thus united, the solid will appear standing, as it were, in relief, between the two plane representations."

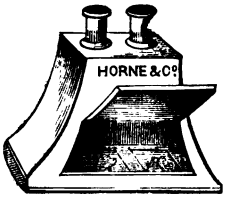


Fig. 114.

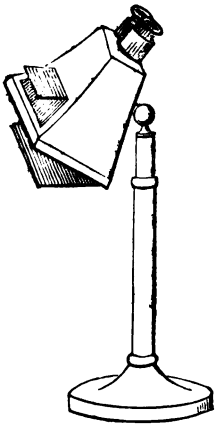


Fig. 116.

The annexed are front and sectional views of the ordinary stereoscope constructed on Sir David's plan (Figs. 114, 115, 116).

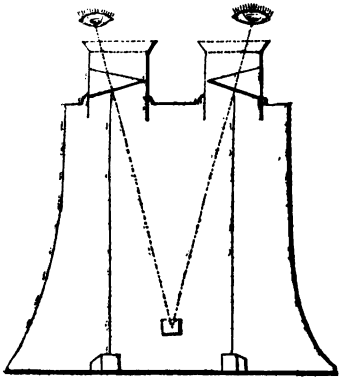


Fig. 115.

Mr. Wheatstone has invented an arrangement which enables us to view larger pictures than we could possibly do in the above. It is called the "reflecting stereoscope," to distinguish it from the lenticular stereoscope, just described.

Two plain mirrors are fixed on a centre support capable of adjustment (Fig. 116.), which is fixed on a mahogany frame into which slide the two arms for holding the pictures. These arms have each adjustments in all directions, so as to bring the two pictures exactly coincident when viewed through the lenses placed in front of the mirrors. These lenses are not essential to the action of the instrument, but add much to the facility of use and beauty of effect. In very perfect instruments, the mirrors are replaced by two polished prisms of glass.

In these stereoscopes the prints must be reversed as they are placed in the drawing, the left-hand one should be the view seen by the right eye in nature, as they are reversed again by being reflected in the mirrors.

There are many rules given for the distance the two cameras should be apart for taking views, &c.; but the reader need not take any trouble about them. The best stereoscopic views ever taken were taken with the two cameras close together. The chief things to be attended to are, that the cameras should be perfectly level, the same height, and that *some object in the view* should come exactly in the centre of each ground-

glass. The latter should be lined (Fig. 118), in order that the amateur may at once be able to do so:—

I need scarcely add that the focus should be perfect in both, and the focal length of the lenses the same. When only one camera is used, it will be necessary to remove it about twelve or fourteen inches, and take care that the same object comes in the centre of the focussing-glass in each case, and that the camera is placed perfectly horizontal and at the same height when moved.

(Fig. 117.)

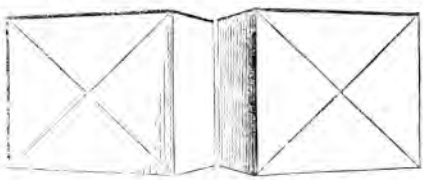


Fig. 118.

Mr. Latimer Clark has published, in the "London Photographic Journal," a very ingenious arrangement for taking stereoscopic pictures with a single camera.

The principle and method of working cannot be better explained than by a reference to his own words.—

"The camera frame, or plate-holder, contains a narrow dark chamber, of the usual construction, capable of receiving a glass plate about $6\frac{3}{4}$ inches by $3\frac{1}{4}$ inches. We will call this portion the slide; it slides to and fro freely within the frame through a space of $2\frac{1}{2}$ inches, or $2\frac{5}{8}$, which is about the distance between the eyes. To admit of this, the frame must necessarily be 10 or 11 inches long, and it therefore requires some simple adaptation to fit it to the end of an ordinary-sized camera. In the front of the frame is an aperture about $2\frac{1}{4}$ inches square, closed by a sliding door, and capable of being contracted by an oval or other shaped diaphragm, which determines the size and form of the two pictures impressed on the plate, and which may be varied at pleasure. The distance between the two pictures is determined by the lateral motion of the slide, viz., $2\frac{5}{8}$ inches, as stated before. After one of the two images has been impressed, the slide has to be shifted laterally at the same instant, and in the same direction as the camera itself, by means which I will presently describe. The second image is then taken, and the frame removed.

"In the foregoing contrivance it is necessary to obtain the focus by a separate glass; but in the Daguerreotype arrangement the focussing-glass forms part of the apparatus; the slide is here in three pieces: the centre piece is the focussing-glass, which, being hinged at the bottom, does not slide, but falls back out of the way. The two side pieces (each of which is a perfect dark chamber, containing a sensitive plate) are now in a position to be drawn successively into the field of view opposite the front aperture, and the images impressed. This makes a very compact arrangement, and requires no door in front of the frame, the plates being exposed to light only when brought opposite to the central opening (Fig.119).

"We now come to the means employed to guide the camera in its lateral movement,

the object being all the while retained in focus. A strongly-framed camera-stand carries a flat table about twenty inches wide by sixteen, furnished with the usual adjustments.

Upon this are laid two flat bars of wood, in the direction of the object and parallel, and about the width of the camera asunder; they are eighteen inches in length; their

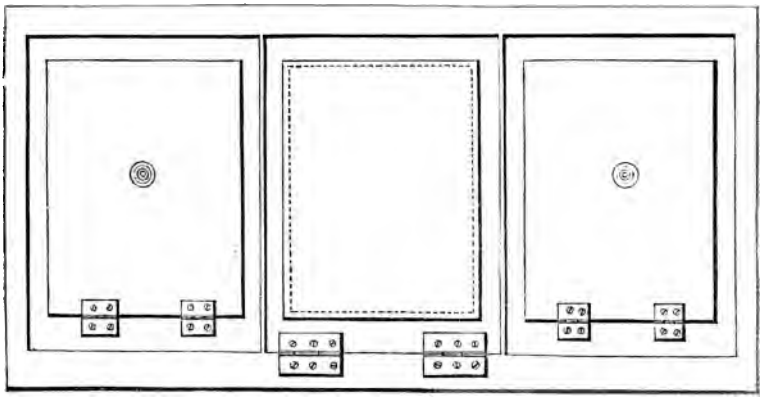


Fig. 119.

front ends carry stout pins, which descend into the table, and form centres upon which they turn; their opposite ends also carry similar pins, but these are directed upwards, and fit into two corresponding holes in the tail-board of the camera. Now when the camera is placed upon these pins, and moved to and fro laterally, the whole system exactly resembles the common parallel ruler; the two bars form the guides, and the camera, although capable of free lateral motion, always maintains a parallel position. In this condition of things, it is only suited to take stereoscopic pictures of an object at an infinite distance; but to make it move in an arc, converging on any object at any nearer distance, it is only necessary to make the two guide-bars approximate at their nearer end so as to converge slightly towards the object; and by a few trials some degree of convergence will be readily found at which the image will remain, as it were, fixed on the focussing-glass, while the camera is moved to and fro; to admit of this

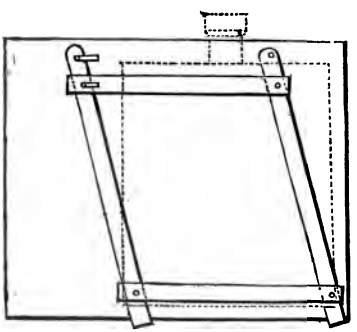


Fig. 120.

adjustment, one of the pins descends through a slot in the table, and carries a clamping-screw, by means of which it is readily fixed in any required position. In order, however, to render the motion of the camera smoother, it is advisable not to place it directly upon the two guides, but to interpose two thin strips of wood lying across them at right angles beneath the front and back of the camera respectively (and which

may be fixed to the camera, if preferred), and to dust the surfaces with powdered soapstone or French chalk.

"Lastly, it is necessary that the slide should be shifted laterally at the same instant as the camera. The means used for this are simple, and consist only of a pulley fixed to the right-hand side of the camera, round which passes a string which is temporarily attached to the slide, the other end being fixed to the left-hand side of the table. When the camera is drawn to the left hand, this string is long enough to allow the slide to be drawn to the left hand also; but when the camera is moved to the right, the re-action of the string draws the slide also over in the same direction, the variations in adjustment being compensated by the intervention of an elastic band.

"The operation of taking a portrait is therefore thus performed. The focus having been adjusted for both positions, and the camera and the slide both drawn to the left hand, the door is raised and the plate exposed—say, for five seconds—by one motion of the hand; the camera is then shifted to the right hand, the slide moving at the same time spontaneously; this occupies less than a second of time; and the plate in its new position having been exposed five seconds longer, the door is closed, and the operation completed—the whole sitting having been supposed to occupy eleven seconds."

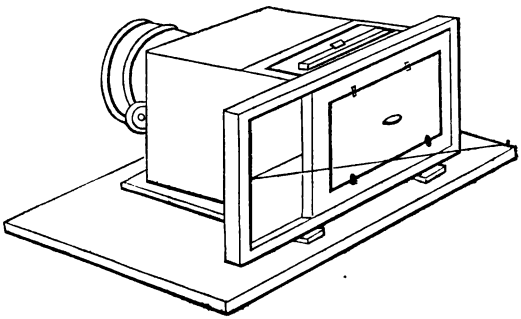


Fig. 121.

The following practical observations by Mr. G. S. Wood will conclude this portion of the present treatise:—

"In the first place, let us ask what it is we have to effect in stereoscopic views? It is simply this—to form upon paper, or glass, or silver (according to the process we may be pursuing), two pictures of the object or objects precisely analagous to those which would be produced on the retinas of the eyes, were we viewing that object or those objects by direct unassisted vision; and the characteristics of those pictures severally should be, that the parts or objects composing such pictures should occupy different relative positions, because, when viewing them in nature, we do so under different angles, or, in other words, that lines drawn from the object or objects under consideration to either eye severally, would form different angles. And it is from the impression which is produced by what may be called the unity of these two pictures (doubtless) in the brain, that we at once have the sensation of rotundity or depth and thickness. And here I would remind those who may not be very conversant with the laws of vision, that the above remark may be easily proved by viewing an object or landscape with *one* eye only; for then all sensation of depth, space, and thickness vanishes; but upon opening the second eye everything stands out in its proper proportions. And I would also observe that the stereoscope has not, strictly speaking, anything to do with producing those impressions of which we have been speaking, but, as we have before stated, the relative positions of the objects viewed by the two eyes severally. The only use of the optical part of the instrument in question is, that by the aid of half lenses placed

in a certain position, we may cause an extraordinary and oblique refraction of the images of the two pictures viewed, in order that they may be produced on these several parts of the retinæ, which it should be borne in mind is indispensable in order to give distinct single vision.

"What has to be done, then, in taking these pictures is this:—After having decided upon the position whence our first view is to be taken, to notice, by a contrivance hereafter to be mentioned, the amount of displacement, so to speak, which the objects composing the view undergo when viewed by either eye singly: of course, keeping the head stationary during the observation, and moving the camera either to right or left (as the case may be), to such an amount that the objects composing the picture, produced on the focussing-glass, shall occupy exactly the same relative positions as the objects themselves did when viewed with each eye singly, as before mentioned.

"And thus, after having stated the broad principles to be observed, I now come to what may more immediately be called the *modus operandi* of the whole affair.

"After having placed my camera—I say camera, for I prefer only one—in a chosen position to take the first view, I place a piece of small wire, or a nail will answer all the purpose, in an orifice made to receive it at the top of the frame of the focussing-glass, so that it may project an inch or two above the frame; and having furnished myself with a staff or stick about five feet long, I force this into the ground about six inches or more from the front of the camera, and as near the centre as possible, without the light entering the lens being interfered with. We will suppose the principal portion of the view to be made up of a dwelling-house, I place, say the right eye; about an inch or so from the wire on the top of the frame before mentioned, and closing the left, I now move the head to such a position that the wire and staff may cut each other, or, in other words, that these two and the eye may be in a line, and notice carefully the part of the landscape whereon these conjointly fall; and we may for illustration sake say, that they are produced on the central bar of the left-hand window of the house. I then, without moving the head, open the left eye and close the right, and I now find that the staff has apparently altered its relative position; it now is produced, say on the extreme right-hand corner of the house itself. Having made these observations, I next note the particular part of the landscape falling upon the centre of the ground-glass, and we will suppose this to be the right-hand side of the doorway of the house. I now proceed to take my first picture. Having done this, I move the camera so much to the left that the wire on the top of the camera and the staff, and the right-hand corner of the house, may cut each other (as the two first-mentioned and the bar of the window did in the first observation), at the same time observing that the right-hand corner of the doorway occupies the same position on the ground-glass as it did previous to taking the first picture. I need hardly add, that in either position the camera should be, as near as can be seen by the eye, at the same level.

"It will at once be seen that it takes infinitely longer to describe the course of procedure than the actually working it out; for the apparatus might be placed in its two positions, and the views taken, all within the space of a few minutes.

I may add, in conclusion, that where these rules are observed in taking stereoscopic pictures, of whatever character the view itself may partake, or however distant some of the objects composing such view may be, they will, when viewed through a stereoscope, convey to the mind impressions precisely corresponding to nature.

Mr. Hardwich gives the following useful hints to the amateur wishing to study

the photographic delineation of microscopic objects, for which he acknowledges himself indebted to the personal kindness of Mr. Joseph Delves, of Tunbridge; as he does also to Mr. Shadbolt, for obligingly demonstrating his mode of working with artificial light.

Some of the specimens of micro-photography which have been exhibited are exceedingly elaborate and beautiful; and their production is not difficult to one thoroughly acquainted with the use of the microscope, and with the manipulations of the collodion process. It is important, however, to possess a good apparatus, and to have it properly arranged.

The object-glass of the ordinary compound microscope is the only part actually required in photography, but it is useful to retain the *body* for the sake of the adjustments, and the mirrors used in the illumination. The *eye-piece*, however, which simply magnifies the image formed by the object-glass, is not necessary, since the same effect of enlargement may be obtained by lengthening out the dark chamber, and throwing the image further off.

Arrangement of the Apparatus.—The microscope is placed with its body in a horizontal position, and the eye-piece being removed, a tube of paper, properly blackened in the interior, or lined with black velvet, is inserted into the instrument, to prevent irregular reflection of light from the sides.

A dark chamber of about two feet in length, having at one end an aperture for the insertion of the eye-piece end of the body, and at the other a groove for carrying the slide containing the sensitive plate, is then attached; care being taken to stop all crevices likely to admit diffused light. An ordinary camera may be employed as the dark chamber, the lens being removed, and the body lengthened out, if required, by a conical tube of gutta-percha, made to fasten into the flange of the lens in front. The whole apparatus should be placed exactly in a straight line, that the ground-glass used in focussing may fall at right angles to the axis of the microscope.

The length of the chamber, measuring from the object-glass, may be from two to three feet, according to the size of image required; but if extended beyond this, the pencil of light transmitted by the object-glass is diffused over too large a surface, and a faint and unsatisfactory picture is the result. The object should be illuminated by sunlight, if it can be obtained, but a bright diffused daylight will succeed with low-power glasses, and especially when only *positives* are taken. Employ the *concave* mirror for reflecting the light on the object in the latter case, but in the former the *plane mirror* is the best, except with powers exceeding a quarter of an inch, and of large angular aperture.

The image upon the ground-glass should appear bright and distinct, and the field of a circular form evenly illuminated; when this is the case, all is ready for inserting the sensitive plate.

The time of exposure must be varied according to the intensity of the light, the sensibility of the collodion, and the degree of magnifying power; a few seconds to a minute will be about the extremes; but minute directions are not required, as the operator, if a good photographer, will easily ascertain the proper time for exposing.

At this point a difficulty will probably occur from the plane of the chemical focus not corresponding, as a rule, with that of the visual focus. This arises from the fact that the object-glasses of microscopes are "over corrected" for colour, in order to compensate for a little chromatic aberration in the eye-piece. The violet rays, in consequence of the over-correction, are projected *beyond* the yellow, and hence the focus of chemical action is further from the glass than the visible image.

The allowance may be made by shifting the sensitive plate, or, what amounts to the same thing, by removing the object-glass a little *away* from the object with a fine adjustment screw; the latter is the most convenient. The exact distance must be determined by careful experiment for each glass; but it is greatest with the low powers, and decreases as they ascend.

Mr. Shadbolt gives the following as a guide:—"An inch and a half objective of Smith and Beck's make, required to be shifted $\frac{1}{20}$ of an inch, or two turns of *their* fine adjustment; a $\frac{2}{5}$ of an inch, $\frac{1}{100}$ of an inch or half a turn; and a $\frac{4}{10}$ of an inch, $\frac{1}{1000}$ of an inch or about two divisions of the adjustment. With the $\frac{1}{4}$ and higher powers, the difference between the foci was so small as to be practically unimportant."

There is also reason to think that the *kind of light* employed has an influence upon the separation of the foci. Mr. Delves finds that with sunlight the difference between them is very small even with the low powers, and inappreciable with the higher; whereas in using diffused day-light, which has undergone a previous reflection from white clouds, it is considerable.

The object glasses of the same maker, and particularly those of different makers, also vary much; so that it will be necessary to test each glass separately, and to register the allowance which is required.

Having found the chemical focus, the principal difficulty has been overcome, and the remaining steps are the same in every respect as for ordinary collodion photographs.

IMPERFECTLY DEVELOPED PROCESSES.

In the preceding pages we have traced the history, step by step, of this wonderful art, through its various stages of Daguerreotype, Calotype, Waxed and Albuminized Paper, and, finally, to the simple and almost perfect Collodion Process. Nevertheless, it must be admitted that numerous indications present themselves, proving that it is yet in its infancy. In this section, therefore, it is proposed to treat of those branches of the subject which are only imperfectly developed, but which are too important to be altogether overlooked. Among these the most remarkable are the results of certain experiments for producing images, with their natural colours, by photogenic action. While numerous experiments have been conducted having this object in view, the American photographers seem to have come closest upon the great desideratum; and the name Hillotype has been given to the process, in honour of the discoverer, Mr. Hill, of West Hill, in the state of New York.

Mr. Hill states that he had undertaken a series of experiments with the object of procuring coloured photographs, but for a long time with little prospect of success; but in one of his experiments certain phenomena presented themselves which greatly surprised him, and persuaded him that the object was attainable. One colour—red—in the figure of a vestment, developed itself in the most brilliant ruby colour; he repeated his experiment many times, but without meeting again the same result, from which he concluded that all the circumstances were not present. Believing, however, that in certain circumstances the latent colour of the image was present, he proceeded with his experiments, and found that the vapour arising from many metals, such as arsenic, cadmium, zinc, selenium, bismuth, potassium, and sodium, possessed the power of developing latent images with their lights and shades. The same result

was obtained with different gases, but the images differed little from the usual results; and he was on the point of abandoning the pursuit, despairing of success.

His joy was, therefore, great when he observed one day that his plate presented a perfect impression in colours. He has followed the same experiment with varying results; but in January, 1851, he obtained forty-five designs, which presented all the different colours and with perfect gradations, the objects represented surpassing the richest Daguerreotypes. These pictures are durable, and soft in their aspect; no doubts are expressed of their permanency, and it is stated that the light does not act upon them. Mr. Hill has not described his process further than that it neither resembles that of M. Daguerre, nor M. Becquerel. Another process, which is quicker in its operation, is mentioned, but without details, except that the yellow colour is that he has the greatest difficulty with.

Sir John Herschel had his attention drawn to this subject so early as 1840. "I got," he says, "some specimens of paper *long kept*, which gave a representation of the spectrum in its natural colours, and that *light* on a *dark ground*; but at present I am not prepared to say that they will prove an available process for coloured photographs, *though it brings the hope nearer*."

M. Biot thinks there are difficulties inherent in photographic pictures, which show that the hopes of the experimenters, who expect to discover the tints of chemical impressions produced by radiation in their natural colours, are illusory.

Mr. Robert Hunt's experiments have, in many instances, given him coloured pictures of the prismatic spectrum *dark* upon a *light ground*; but the most beautiful has been obtained upon the Daguerreotype iodized tablets, on which the colours have at the same time had a peculiar softness and brilliancy. Again, during January, 1854, he prepared some paper with the bichromate of potash and a very weak solution of nitrate of silver, which he exposed behind four coloured glasses, which admitted the passing—1st, of violet, indigo, and blue rays; 2nd, of blue, green, and a portion of yellow rays; 3rd, of green, yellow, and orange rays; and 4th, of orange and red rays. Being allowed to lie for two days—extremely foggy days—opposite a window having a southern aspect, it was found on examination that the paper had become tinted of a blue, green, and red; beneath the yellow glass the change was uncertain, from the peculiar colour of the paper. All this took place without a single gleam of sunshine. This and some other experiments proved to his satisfaction, that the *possibility* admitted by Sir John Herschel amounted to a probability.

M. Becquerel has succeeded in obtaining bright impressions of the spectrum in colours, and in copying highly-coloured drawings on metallic plates prepared with chlorine; and M. Niepce de St. Victor observed that chloride of sodium was employed upon a silver plate plunged into a solution of sulphate of copper, and the plate became more susceptible of receiving a yellow colour than any other.

Looking at these results, and assuming that Mr. Hill's statements are trustworthy, it seems probable that means will be found for producing coloured images both on silvered plates and on paper.

Photography Applied to Lithography.—Some very important applications of the art to engraving on steel and lithographic stone are also named. Among these we may quote the process of Mr. Macpherson, of Rome, as communicated by Mr. Ramsay to the British Association. Mr. Macpherson had succeeded in obtaining beautiful photo-lithographs, specimens of which had been hung up in the Photographic Institution in Buchanan Street, Glasgow. The steps of the process are as follows:—

1. Bitumen is dissolved in sulphuric ether, and the solution is poured on an ordinary lithographic stone. The ether quickly evaporates, and leaves a thin coating of bitumen spread uniformly over the stone. This coating is sensitive to light—a discovery made originally by M. Niepce, of Chalons.

2. A negative on glass or waxed-paper is applied to the sensitive coating of bitumen, and exposed to the full rays of the sun for a period longer or shorter, according to the intensity of the light, and a faint impression on the bitumen is thus obtained.

3. The stone is now placed in a bath of sulphuric ether, which almost instantaneously dissolves the bitumen, which has not been acted on by the light, leaving a delicate picture on the stone, composed of bitumen on which the light has fallen.

4. The stone, after being carefully washed, may be at once placed in the hands of the lithographer, who is to treat it in the ordinary manner with gum and acid; after which proofs may be thrown off by the usual process.

Professor Ramsay then proceeded to state that the above process, modified, had been employed with success to etch plates of steel or copper, without the use of the burin:—1. The metal plate is prepared with a coating of bitumen, precisely in the manner noticed above. 2. A positive picture on glass or paper is then applied to the bitumen, and an impression is obtained by exposure to light. 3. The plate is placed in a bath of ether, and the bitumen not acted upon by the light is dissolved out; a beautiful negative remains on the plate. 4. The plate is now to be plunged into a galvano-plastic bath, and gilded; the gold adheres to the bare metal, but refuses to attach itself to the bitumen. 5. The bitumen is now removed entirely by the action of spirits and gentle heat; the lines of the negative picture are now represented in bare steel or copper, the rest of the plate being covered by a coating of gold. 6. Nitric acid is now applied as in the common etching process; the acid attacks the lines of the picture formed by the bare metal, but will not bite into the gilded surface. A perfect etching is thus said to be obtained.

Application of Photography to Astronomy.—The Roman astronomers state that they have procured photographic impressions of the nebula of the sword of Orion; and Mr. Brooke has invented an apparatus intended for the self-registration of the vertical and horizontal oscillations of the magnet, and the various readings of the barometer and thermometer throughout the day and night, by means of artificial light and photographic paper. This is a very useful and important application of photography to self-registering purposes, and has been found to give perfectly accurate results, and, of course, much more complete than the former system of hourly observations, to make which an assistant had to sit up throughout the night. This invention is altogether due to Mr. Brookes.

The only other application which has hitherto been made of photography to astronomical purposes, so far as we are aware, has been in taking Daguerreotype images of the moon and the solar spots. In the former case, the ordinary preparation of the silvered plate and glass, as used in the Daguerreotype and Collodion processes for taking portraits, is quite delicate enough. A very beautiful image of the moon, when about half-full has been taken in this manner with the great telescope of twenty-three feet focal length and fifteen inches aperture, at Cambridge in the United States. It was taken by Mr. Bond and was four or five inches in diameter. It has likewise been attempted with the great equatorial at the Cambridge Observatory, but the clock motion, for keeping the telescope pointed to the same part of the heavens, has not yet been found steady enough

for that purpose, and the photographs obtained have been imperfect. In taking them, the image given by the object-glass alone (without any intermediate lenses) has been received on the plate.

In the case of the solar spots, any ordinary photographic paper is, of course, quite delicate enough. In many observatories an image of the sun's disc has been taken from time to time in this manner.

An image of a *double star* has likewise been taken, but the other remarkable sidereal objects, as nebulæ, clusters, &c., shine with too faint a light to be registered by the most delicate preparation of the plate yet known. It has hitherto failed altogether with Lord Rosse's gigantic reflector, though an image of the moon taken by this instrument would be of great value.

Photographs from Electric Light.—It was at one time assumed that artificial light possessed no chemical rays; but Mr. Brande set aside this notion, having discovered that although the concentrated light of the moon, or even the light of olefiant gas, composed of equal parts of carbon and hydrogen in its most intense form, had no effect on chloride of silver or on chloride and hydrogen. Yet the light emitted by electrized charcoal blackens the salt, while pictures have been taken upon sensitized paper by means of the electric light. For portraits this process is rendered difficult by the intensity of the light affecting the sitter's sight; but for microscopic objects, and especially with the oxyhydrogen microscope, it has been more successful. A correspondent, who pursued these investigations with great success, thus explains himself:—"The object of my experiments was to obtain good photographs of microscopic objects, and having the opportunity of employing Mr. Haite's electric light, I did so with very satisfactory results. I also succeeded in obtaining one or two portraits by it, but the latter were marked by great severity of shadow, even when the light was painfully intense and unpleasantly hot. I concluded therefore that the amount of actinic ray was but small in comparison with the luminous character of the light; the calorific rays were, however, abundant. The same disproportion I have observed with respect to the Drummond light and with gas. While the direct rays are actinic, artificial light does not appear to have the same radiating power on the atmosphere which we observe in solar light, and which produces the fine illumination of objects in partial or complete shadow. This deficiency, I believe, I have observed in some states of the atmosphere in daytime, when, with a comparatively strong light, actinic effects have been feeble, and particularly deficient in the *radiant* quality."

To those who cannot devote their time to photography during the day, Mr. Shadbolt's observation on the use of artificial light may be of service. He employs *camphine*, which appears to give a whiter flame than either gas or the moderator lamp; placing the source of light in the focus of a plano-convex lens of two and a half to three inches diameter (the flat side towards the lamp), and condensing the parallel rays, so obtained, on the object, by a second lens of about an inch and a half diameter and three inch focus.

This mode of illumination, being feeble as regards chemical rays, is best adapted for object-glasses of low power. The exposure required to produce a negative impression with the one-inch glass may be from three to five minutes. The development is conducted in the ordinary manner.

Particular stress is laid upon the object-glass of the microscope being a good one for the purpose; and indeed all who have given attention to the subject are agreed upon this point—that there is a considerable difference in the photographic value of objectives, and this, too, independent of the angular aperture of the glass.

The Rev. W. Towler Kingaley has communicated a process by which very beautiful microscopic photographs have been obtained. He illuminates (in the absence of sunlight) with the brilliant light produced by throwing a jet of mixed oxygen and hydrogen gases upon a small cone of lime or magnesia. His process is as follows:—

It is not necessary to describe the method of making collodion. With it a very small quantity of iodide of silver, dissolved in iodide of potassium or in cyanide of potassium, is mixed. This is now to be poured on a plate of glass, and the excess poured off again, so as to leave a film of the preparation on the glass surface. The plate is now to be plunged into a bath of nitrate of silver, 30 grains to the ounce of water; and as soon as the whole of the plate will retain the water without running into streaks, the plate is to be exposed to the action of the light; it is then to be plunged into a bath of pyrogallic acid, 3 grains; water, 1 ounce; glacial acetic acid, 1 drachm. This deiodizing and deoxidizing bath develops the image; the unreduced iodide is then to be removed by hyposulphite of soda. This is the ordinary process, and the method is simple and good. If we add to the collodion mixture a small quantity of iodide or bromide of iron, and develop with protonitrate of iron, the process is rendered much more energetic; for we obtain on the plate, as soon as it goes into the silver bath, nitrate of iron, which deiodizes the plate as soon as the light strikes it. I do not find these preparations of iron to keep well, and therefore the preparation should be made only a short time before it is to be used. Iodide and bromide of arsenic are also admirable accelerators, and appear to keep for months without change; with them either the pyrogallic solution or protonitrate of iron may be used. I may here mention that albumen, treated exactly the same as the collodion, only dried and heated after being poured on the glass, acts just as well and as quickly.

I shall now describe the method of preparing the paper used. I prefer Canson's paper. I have no doubt that many others are just as good.

It is used either waxed or not, with nearly the same results; but the waxed paper is the more easily managed, on account of its not becoming so tender from soaking. The paper is first to be soaked for some hours in a bath composed as follows:—

Distilled water	1 pint.
Iodide of potassium	half an ounce.
Bromide of potassium	half a drachm.
Fluoride of potassium	1 drachm.
The whites of two eggs.	

If this is done under the air-pump so much the better. The paper is now to be hung up to dry, sheet by sheet; and so prepared it keeps well, certainly for months. If arsenic be added, as in the collodion, the paper is more sensitive. When it is to be used, it is to be plunged into a bath composed as follows:—

Nitrate of silver	30 grains.
Acetic acid	½ drachm.
Distilled water	1 ounce.

After the paper has become saturated in this bath, it is to be placed on a sheet of pure blotting-paper, and that on a sheet of glass, to which it will adhere from the superabundant fluid; it is now to be exposed to the action of the light for the required time, which of course depends upon the intensity of the light; with my microscope, from two to five minutes is quite enough. It is then to be developed in a bath of saturated gallic acid; if the image does not seem dark enough in an hour, a few drops

of the silver bath should be added. Hyposulphite of soda, as usual, is the fixing agent. The silver may be used over and over again, if it be filtered with animal charcoal after each time it is used, or as soon as it shows the least sign of becoming discoloured.

In these processes we have the affinity for the iodine disturbed by the action of the light; the developing agent carries this further, and the oxygen of the air or water or acid, which has always a slightly greater affinity than iodine for silver, combines with the liberated silver and produces the dark parts of the impression; if the action is carried still further we get the silver revived; and in the collodion process this produces a positive. To obtain these collodion positives, the quantity of silver in the collodion should be small, and the exposure only for an instant; after the plate is developed and fixed it should be put into a bath containing either aldehyde or grape-sugar, which will revive the silver with great brilliancy. The paper pictures may be developed by placing them in the mercury box; but it is not to be recommended. There is one use of the collodion which is of service. In the use of very high powers with very delicate objects, it is not easy to see the image formed on the vesculine screen, as described hereafter. When, therefore, an approximate focal distance has been obtained, a collodion positive on a small scale of a portion of the image

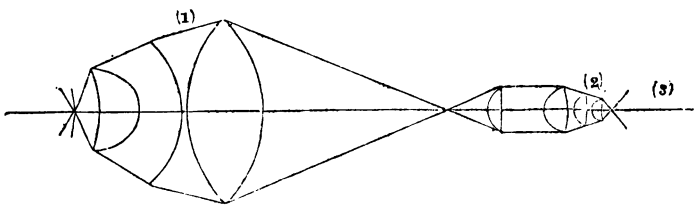


Fig. 122.

can be taken in a few moments, and so the correctness of the arrangements tried before placing the paper in its place.

I shall now proceed to describe the instrument used. Sunlight is of course far superior to any artificial light, when we can obtain it; but as the sun will not shine whenever we choose, it is of the greatest importance to construct the instrument for artificial light, and then modify it so as to be applicable to sun light. The light I use is the common oxyhydrogen light; magnesia or quartz may be substituted for lime-ball with advantage.

The optical parts of the instrument divide themselves into four groups—the light-collecting, the condensing, the objective and magnifying lenses. The first group (1), for collecting the light, consists of three lenses; the first a meniscus of about three inches focal length and two and a half diameter, the second plano-convex with the radii of the surfaces one and six; the focal lengths of these two lenses being respectively six and eight inches.

The second group, or condensing lenses (2), is a similar one turned the other way, and on a reduced scale, to suit the different object-glasses; between these two systems there is a plano-convex placed at its focal length from the focus of the collectors, so as to allow the rays to pass parallel to the condenser. This lens and the condensers must be changed with the object-glasses; for it must be borne in mind that we have

to arrange the instrument so as to make the image of the lime-ball just cover the paper to be acted upon; and if we diminish the focal lengths of the condensers at the same time that we increase the magnifying power of the instrument, we shall have just as great an amount of light with the highest as with the lowest powers.

The next group of lenses are those of the object-glass (3), which requires to be very much under corrected for visible colour, leaving strong red fringes. A very simple way of making the object-glasses of an ordinary good microscope do for photographic purposes is to have a new front lens made for them, so that they can be used for either the ordinary or the photographic microscope. At this point of the arrangement we have a very good form of the oxy-hydrogen microscope; but it is a bad one for photography, as we cannot have the screen on which the image is to be formed so near as to enable us to use the slow motions of the various arrangements at the time we are looking at the image, except for very low powers.

We now come to the last group, which occupies the place of the eye-piece of the ordinary compound microscope. This group is a form of the Ramsden or positive eye-piece, which ordinarily consists of two plano-convex lenses, placed at two-thirds their focal length, which is the same in both, and with their plane sides out (4). This eye-piece is not achromatic, being under corrected. The addition of a plano-concave flint lens to a double convex crown is used in the place of the lens next the object. This enables me, by a slight change of distance, to make the correction perfect.

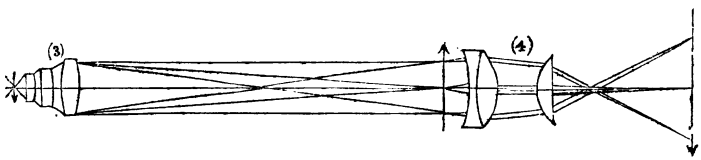


Fig. 123.

I have now only to describe the best way of using this instrument; and here, it must be remembered, that all depends upon the object-glass being good. It is very easy to get one of small angle that will give very sharp outlines of objects, but we must not be content with such images as these; we must get object-glasses of large angular aperture, made perfect for this purpose, so as to show the structure of objects, as well as their outlines. This is quite feasible. Suppose, then, that we have got a perfect instrument.

At the place of the focus of the object-glass place a screen of æsculine, and a dark blue glass between the collectors and condensers; we shall now, "thanks to Professor Stokes," see the chemical image; and the correction for spherical aberration must now be made in the ordinary manner. Now put in the eye-glass or magnifier, and the æsculine at the screen, and adjust the focus. This focus will be found, even in the case of chemically corrected lenses, beyond the visible; but in the case of the ordinary best object-glasses, the difference is enormous; for instance, in the case of a very fine one-fifth in my possession, if I form an image of one foot from the eye-glass, I find the chemical image ten feet further back; of course such a lens is of no use for photography.

The æsculine also enables one to see at once when the light on the screen is the most intense for chemical action.

In conclusion, I have to state that some of my specimens sent were taken upon a disc of five feet diameter, which was illuminated equally; and therefore anything may be taken on that scale on paper with artificial light, and I dare say on a very much larger scale still. I look upon it, therefore, that we must give our chief attention to the corrections of the lenses, as all the other parts of the process seem to require little further than mere care in the use of common formulæ. I have also to add, that the focal length of the condenser being selected, in order to give the image of the incandescent spot of lime on the right scale, its angular aperture should be a shade less than that of the object-glass.

By this process, if a spot of tinfoil be placed on the condenser, we can get the object bright on a dark ground; and if an opaque object be placed in the focus of the collecting lenses, and the object-glass and eye-piece be turned round to the front of the object, a very good image may be got with low power.

Photographs on Wood.—Among other applications of this art, we must not omit to name it as an aid to the wood-engraver, to the extent of giving a perfectly faithful tracing of the landscape or portrait which he proposes to engrave. At the first page of our treatise we have given the negative and positive of a very characteristic portrait traced on the wood by this process, and engraved without penciling after it had been laid aside for nearly two years. It was supposed for a long time that the chemical means required to make the wood sensitive to the actinic action would destroy its fibre, and render engraving impossible; but this is not the case. The correspondent who kindly made these experiments for us thus explains himself. After explaining the difficulties experienced from imperfect apparatus, he says:—

"I must tell you what I conceive I have achieved by this block, and point out the probabilities of ultimate success. I have produced a positive picture without staining the wood, and which is removable when the engraving is done, should that be necessary. All, then, that remains to be done is to get a perfect negative, that will give a reverse image on the wood; and this may be accomplished in this manner:—The cameras constructed for Daguerreotypes have a reversing prism, which gives a correct image, and consequently would produce a correct negative; when this is transferred to the wood, it would produce a reverse positive picture (the thing wanted). I should wish to have this block engraved and printed, to make sure that there is nothing on the wood itself to prevent or interfere with the printing process. I am sure there is nothing to interfere with the engraver's art, as the scratch of a pin reveals the white wood. I consider, that if the engraving and printing are successful, the success of the other part is certain. There are a great many chances yet of something else turning up; but it would require a camera constructed on purpose, so as to allow blocks of wood to be adjusted in it—no very difficult problem. I can produce a white picture on a black ground directly from the object; but I much fear that the blackening of the wood would spoil the block for the engraver; and also, I think this promises to answer every purpose."

Colouring Photographic Pictures.—Artificial colouring, whether applied to Daguerreotype or photography, is by no means a happy idea. To colour them in a satisfactory manner requires the talent of a first-class miniature painter; and it need not be stated that this can rarely be obtained. Nevertheless, some of our readers may desire to try the experiment; we transcribe here various colouring processes for those so disposed.

Nearly, if not quite all the various colours used in painting may be made from the

five primitive colours, black, white, blue, red, and yellow; but for the Daguerrean artist it would be the best policy to obtain such as are required by their art already prepared. In a majority of cases, the following will be found sufficient, viz., carmine, Prussian blue, white, chrome yellow, gamboge, for drapery; yellow ochre for the face, or all three; light red; indigo; burnt sienna; bistre, or burnt umber.

If, in colouring any part of a lady's or geutleman's apparel, it is found necessary to produce other tints and shades, the following combinations may be used:—

Orange—Mix yellow with red, making it darker or lighter by using more or less red.

Purple—This is made with Prussian blue, or indigo and red. Carmine and Prussian blue producing the richest colour, which may be deepened in the shadows by a slight addition of indigo orbrown.

Greens—Prussian blue and gamboge makes a very fine green, which may be varied to suit the taste of the sitter or operator, by larger portions of either, or by adding white, burnt sienna, indigo, and red, as the case may require. These combinations, under different modifications, give almost endless varieties of green.

Brown—May be made of different shades of umber, carmine and lamp-black.

Neutral tint—Is composed of indigo and lamp-black.

Crimson—Mix carmine and white, deepening the shaded parts of the picture with addititional carmine.

Flesh colour—The best representative of flesh colour is light red, brightened in the more glowing or warmer parts with carmine, softened off in the lighter portions with white, and shaded with purple and burnt sienna.

Lead colour—Mix indigo and white in proportions to suit.

Scarlet—Carmine and light red.

For jewelry—Cups of gold and silver preparations accompany each box for Daguerreotypists, or may be procured separately.

The method of laying colours on Daguerreotypes is one of considerable difficulty, inasmuch as they are used in the form of perfectly dry impalpable powder. The rules we shall give for colouring Daguerreotypes depend, and are founded, upon those observed in miniature painting, and are intended more as hints to Daguerreotype artists in hopes of leading them to attempt improvements, than as instructions wholly to be observed.

The writer is confident that some compound or ingredient may yet be discovered which, when mixed with the colours, will give a more delicate, pleasing, and natural appearance to the picture than is derived from the present mode of laying them on, which in his estimation is more like plastering than colouring.

In colouring Daguerreotypes, the principal shades of the head are to be made with bistre mixed with burnt sienna, touching some places with a mixture of carmine and indigo. The flesh tints are produced by the use of light red, deepened towards the shaded parts with yellow ochre, blue, and carmine mixed with indigo, while the warmer or more highly-coloured parts have a slight excess of carmine or lake. Colour the shades about the mouth and neck with yellow ochre, blue, and a very little carmine, heightening the colour of the lips with carmine and light red, letting the light red predominate on the upper and the carmine on the lower lip; the shades in the corner of the mouth being touched slightly with burnt sienna mixed with carmine.

In colouring the eyes, the artist will of course be guided by nature, observing a very delicate touch in laying on the colours, so as to preserve as much transparency as

possible. A slight touch of blue—ultramarine would be best if it would adhere to the Daguerreotype plate—in the whites of the eyes near the iris, will produce a good effect.

In colouring the hands of men it will be necessary to use the darker tints with more freedom, according to the complexion of the sitter. For women the warmer tints should predominate, and in order to give that transparency so universal with the softer sex—and which gives so much loveliness and beauty to the face—a little white may be judiciously intermingled with the red tints about the lighter portions of the face.

In taking the likeness of a lady with light or auburn hair, by the Daguerreotype process, much of the beauty of the face is destroyed, on account of the imperfect manner in which light conveys the image of light objects to the spectrum of the camera; and this, I conceive, is an instance where defects may be obviated in some measure by proper colouring. To do this touch the shaded parts with burnt sienna and bistre, filling up the lighter portions with yellow ochre, delicate touches of burnt sienna, and in those parts which naturally have a bluish tint, add very delicate touches of purple—so delicate, in fact, as hardly to be perceived. The roots of the hair at the forehead should also be touched with blue, and the eyebrows near the temples made of a pinkish tint. The chin of a woman is nearly of the same colour as the cheeks in the most glowing parts. In men it is stronger and of a bluish tint, in order to produce the effect given by the beard.

In portraits of woman—the middle tints on the side of the light, which are perceived on the bosom and arms, are made of a slight mixture of ochre, blue and lake, (or carmine), to which add, on the shaded sides, ochre, bistre, and purple; the latter in the darker parts. The tints of the hands should be the same as the other parts of the flesh, the ends of the fingers being a little pinkish and the nails of a violet hue. If any portion of the fleshy parts is shaded by portions of the dress, or by the position of the hand, this shade should be coloured with umber mixed with purple.

To Colour the Drapery.—*Violet velvet.*—Use the purple made of Prussian blue and carmine, touching up the shaded parts with indigo blue.

Green velvet.—Mix Prussian blue and red orpiment, shade with purple, and touch up the lights with a little white.

Red velvet.—Mix a little brown with carmine, shading with purple, marking the lights in the strongest parts with pure carmine, and touch the most brilliant slightly with white.

White feathers—May be improved by delicately touching the shaded parts with a little blue mixed with white. *White* muslin, linen, lace, satin, silk, &c., may also be coloured in the same way, being careful not to lay the colour on too heavily.

Furs.—*Red furs*—may be imitated by using light red and a little masticot, shaded with umber.

Gray furs—black and white mixed and shaded with bistre.

Sable—white shaded lightly with yellow ochre.

These few directions are quite sufficient for the art, and it is quite unnecessary for me to pursue the subject further. I would, however, remark that the Daguerreotypists would find it greatly to their advantage to visit the studies of our best artists, our public galleries of paintings and statuary, and wherever else they can obtain a sight of fine paintings, and study the various styles of colouring, attitudes, folds of drapery, and other points of the art. In colouring Daguerreotypes, artists will find the magnifying glass of much advantage in detecting imperfections in the plate or in the image, which may be remedied by the brush. In selecting brushes choose those most susceptible of a fine point, which may be ascertained by wetting them between the lips or in a glass of water.

Glycerined Collodion.—I need scarcely tell the reader that there are, discoveries in Photography being made daily. Even while this treatise is going through the press, several of importance have been published, both in the chemical and mechanical part of the science; for instance, in close alliance with the moist collodion, the honey collodion, and the collodio-albumen processes, comes the employment of glycerine for the purpose of preserving the sensitiveness of collodion for a lengthened period. Mr. H. Pollock writes as follows:—

"I have lately adopted a mode of applying glycerine to collodion plates in order to make them keep, which is, I believe, new, and which, from its simplicity and (as far as I have tried it) certainty, will, I trust, prove of general utility.

"1. To ordinary collodion add glycerine in the proportion of six drops to the ounce.

"2. Make a nitrate of silver bath in the usual manner, except that, instead of distilled water, a mixture of glycerine and distilled water, in the proportion of one of the former to five of the latter, is to be used.

"3. Make a second bath, containing only six grains of nitrate to the ounce.

"4. Coat the plate with 1, and immerse it in 2, in the usual manner, after which immerse it in 3, for a minute; drain it as usual, and you have a keeping plate, which I find to be as good at the end of a week as when fresh from the bath.

"5. Before developing, moisten the plate with distilled water, then proceed as usual, taking care to add two drops of a 50-grain solution of nitrate of silver to the developing solution before pouring it on to the plate.

"Note 1. For a short time I imagined (contrary to my expectation) that glycerine did not decompose a solution of nitrate of silver; I was, however, misled by the slowness of the action, for it does produce decomposition, although very slowly, even in the dark. This does not appear to damage the bath (it certainly does not for a month), but makes it necessary to filter it about once a week. In time the bath would probably become alkaline and require the addition of fresh nitrate and acetic acid.

"Note 2. Six drops of glycerine to the ounce of collodion is perhaps a maximum dose. If too much is added, the film will have a honey-combed structure; the quantity which can be added without producing this, will vary with the quantity of water present in the collodion; hence the collodion best fitted for this process is that made with anhydrous ether and alcohol, and it must be borne in mind that in actual use the proportion of glycerine will gradually increase, because the ether and alcohol evaporate, but the glycerine remains.

"Note 3. If Note 1 is supposed to contain an objection to this method, a horizontal bath can be used holding but little, and a new bath be mixed once a fortnight.

"Note 4. The glycerine used is prepared, by decomposing fats by high-pressure steam, by Price's Patent Candle Company, and which can be easily procured.

"Note 5. My experience of this process is very short. I therefore have given proportions, not as being the best, but such as I have found succeed. More extended experience must show what is the minimum of glycerine which will produce the maximum keeping effect."

And Mr. Maxwell Lyte has brought before the world a new system of printing which "depends on the power which aqua regia possesses of destroying sulphide of silver, or any similar compound of sulphur, converting the metal into a chloride, while at the same time the combined sulphur becomes sulphuric acid. The sulphur thus becomes soluble, while the silver takes the form of a chloride; and having thus got rid of the sulphur, we again darken the chloride of silver by acting upon it

with a combination of gallic acid and potash, which reconverts it to the black metallic state. Take ordinary positive paper. The papier Saxe is, perhaps, most suited to the purpose, as giving the greatest fineness and most perfect definition. Having chosen the right side, lay that side downwards on a solution of chloride of ammonium of five per cent. When it has thoroughly imbibed, lift it off, and hang it up to dry; then lay the same face down on a bath of nitrate of twenty per cent., and after it has been for at least five minutes in contact with this bath, again suspend it to dry.

"Print the picture in the usual way, only let it be printed somewhat darker than will be ultimately required, as the after process tends rather to tone it down.

"The print withdrawn from the pressure-frame must now be placed in a bath of plain water, in order to extract as much as possible of the free nitrate; then in a bath of water in which is dissolved a little salt. This converts all the free nitrate remaining in the proof into chloride of silver, and from thence it is to be carried to a bath of new hyposulphite of soda of 25 per cent., to which has been added 0·5 per cent. of carbonate of soda. Here it is to remain till fixed, which process may be deemed accomplished after it has lain for from a quarter of an hour to half an hour in the bath. It is now to be thoroughly washed in several waters till all the hypo be removed.

"The picture will now be most probably of an ugly red colour, the more strongly so in proportion as the hypo is more freshly made; and if by age of the hypo the picture may happen to be of a better tone, then the presence of sulphide of silver in the proof always seems to threaten its destruction if left there, but the existence of which the following treatment obviates. The well-washed and still wet proof is now placed in a bath composed of aqua regia, eight or ten parts; water, one hundred parts. Here it is seen rapidly to fade, and after a short time will have almost completely disappeared, the dark silver forming the picture having all become converted into chloride; while the sulphur, if any there is, is at the same time converted into sulphuric acid, and dissolved out into the liquid. It is now transferred into a bath of water, to which has been added a morsel of carbonate of soda, or a few drops of ammonia, so as to get rid of the acid, and may then be placed in the following bath:—Water, one pint; gallic acid (saturated solution in alcohol), two or three drops; liquor potassæ, one drop; to be mixed at the moment of using. In this mixture the proof rapidly darkens, re-appearing in all its minutest details, and requiring no further treatment than a slight washing in clean water, when it has arrived at its maximum of intensity.

"I may here add a few remarks. The paper employed for this process should not be sized with gelatine, albumen, or any other animal preparation, but with the vegetable preparation used for the machine-made papers which are made on the continent.

"The bath of gallic acid absorbs oxygen very rapidly from the atmosphere, becoming red, so it soon spoils; therefore the ingredients should not be put together until the moment when they are required for use. The small quantity of these substances used at each time prevents all question as to expense, and the time employed in producing a picture scarcely, if at all, exceeds that demanded by any other process, long as this description may appear. This method is, of course, equally applicable for the treatment of positives made by the negative process, *i.e.*, by development; but to my idea this last-named process possesses one great disadvantage, viz., our being unable to watch the progress of the printing, and thereby to stop it at just the right point—a condition absolutely necessary to the production with certainty of perfect positives.

"As the above mode of printing abstracts all the size from the paper, it is necessary either to resize it, or to rub it over with an encaustic prepared thus: take some white

wax and dissolve it in turpentine to form a mixture of about the consistence of pomatum, and add to this a quantity of alcohol equal in bulk to half the turpentine employed. Having then fixed the proof either into a frame for stretching drawing-paper in, or having pasted it on a piece of paper and fixed it down, rub into the face of it the paste of wax, &c., and as quickly rub it off with a piece of clean flannel. Enough of the wax remains on the face of the picture to render it beautifully bright and clear, and at the same time to render it impervious to air and moisture, and it may be now cut down and mounted.

"Lastly, as each paper sensitized extracts from the bath a certain amount of nitrate, it becomes necessary to add, for each whole sheet or number of small sheets equalling a whole sheet, which have been sensitized, one drachm of nitrate of silver in crystals, adding at the same time water to make up the quantity of the liquid to its original volume; and also, to avoid loss by the drip from the paper when hung up, it is well to draw its lower surface, *i.e.*, the side which has lain on the bath, over a glass rod held in an oblique position in such a manner as that the liquid which it scrapes off from the face of the paper may fall back again into the bath."

SUMMARY OF PROCESSES FOR PREPARING PAPER.

1. *Bayard's Process.*—Take some drawing-paper, spread over it a solution of bromine of potassium, afterwards a solution of nitrate of silver; expose this paper for some minutes to the action of light in a dark room; make the image visible by means of mercurial vapour, as in Daguerre's process.

2. *Becquerel's Process.*—A modification of the method of Panton, which see.

3. *Chenning's Process.*—1st. Dissolve sixty grains of nitrate of silver in one ounce of water. 2nd. Dissolve ten grains of iodine of potassium, or a mixture of one part of bromine of potassium and two parts of iodine of patassium, in one ounce of water. 3rd. Wash the paper with the first, and afterwards with the second solution, and dry it.

4. *Cundell's Process.*—1st. Spread over the paper a solution of thirty grains of nitrate of silver. 2nd. Plunge it into a solution of iodine of potassium, two hundred grains of this salt in seven thousand parts of water, to which add thirty grains of sea salt. Place the prepared side of the paper in contact with the surface of this liquid. 3rd. Leave the paper for five or six minutes floating on the distilled water, dry it in the air, and press it and make it smooth. 4th. Make the impression appear by a solution of concentrated gallic acid, mixed with the same quantity of solution of nitrate of silver, fifty grains of salt, dissolved in one ounce of distilled water, and with a sixth part of acetic acid.

5. *Daguerre's Process.*—Chloride of silver paper. Take some paper slightly covered with isinglass, plunge it in hydrochloride water dried in the open air. When dried put it on the prepared side in contact with a solution of nitrate of silver; dry it and preserve it without exposing it to the light.

6. *Fyfe's Process.*—1st. Dip the paper in a solution of phosphate of potash (one part of this salt in eight parts of water), then dry it. 2nd. Cover it, with the help of a paint brush, with a solution of nitrate of silver (one part of this salt in six parts of water), then dry it again. 3rd. Dip it a second time in the solution of phosphate of potash. 4th. Fix the impression by means of a spreaded solution of one part of ammonia in six parts of water, which will only dissolve the salt of silver, not impressed by the light, whilst it does not affect the blackened salt.

7. *Gaudin's Process.*—1st. Expose the paper during one minute to the vapour of

of hydrochloric acid. 2nd. Cover it over with a solution nearly saturated with nitrate of silver. 3rd. Develop the image, after the action of light in the dark room, covering the paper with a concentrated solution of sulphate of iron slightly acidulated with sulphuric acid. 4th. Fix the image by washing with water containing a tenth part of caustic ammonia.

8. *Process of Heeron.*—1st. Plunge some thin white paper, for a quarter of an hour, in a solution of nitrate of silver, prepared by mixing one part of salt in five parts of water; then plunge it for the same space of time in a solution saturated with sea salt; wash it with distilled water, press it out and dry it between sheets of blotting-paper.—*Note.* This photographic paper is used to judge of the intensity of light in the preparation of Daguerreotype plates.

9. *Herschel's Process.*—1st. Mix, with the help of a gentle heat, a solution of nitrate of silver, of 1·200 density, with two parts of tartaric acid of 1·023 specific gravity, by treating the ferro-tartaric of ammonia with acetate of lead, and decomposing the precipitate with diffused sulphuric acid. 2nd. Wash the paper again with this solution and dry it in the dark.

10. *Herschel's Chrysotype Process.*—1st. Dip the paper in a solution of one hundred grains of crystallized ammoniacal citrate of iron in one hundred grains of water. 2nd. Let it be half-dried. 3rd. Develop the image by a solution of chloride of gold dissolved in water, completely neutralized by potash. 4th. Dip it at first into the water, then for two minutes in a solution of iodine of potassium; then wash it again in the water.

11. *Herschel's Cyanotype Process.*—1st. Dry in equal portions a concentrated solution of corrosive sublimate with a solution of ammoniacal citrate of iron, mixed with eleven parts of water. 2nd. Cover the paper with it, and dry it. 3rd. Wash the image with a concentrated solution of cyano-ferrate of potash, mixed with three times its volume of gum-water.

12. *Horsley's Process.*—1st. Dip the paper in a watery dilution of sea salt, or one hundred and twenty grains of sal-ammonia in one ounce of water, and dry it. 2nd. Impregnate the paper with a liquor made of a mixture of one hundred and eighty grains of ammonia, sixty grains of nitrate of silver, and five grains of suberic acid, and dry it by the fire. 3rd. Leave it from five to ten minutes in the camera. 4th. Fix the image with hyposulphate of potash, wash the paper, and dry it by the fire.

13. *Hunt's Process.*—1st. Dissolve one part of nitrate of silver in four parts of distilled water, and cover one side of the paper with this solution. 2nd. Dip the paper, after drying it, in a solution of iodine of potassium (one part of the salt in eight parts of water), leave it there during one minute, and wash it afterwards with distilled water. This paper will keep a long time, and can be rendered sensitive immediately by washing it with a solution of cyano-ferrate of potassium (one part of salt in four parts of water).

14. *Hunt's Energetype Process.*—Wash the paper with a saturated solution of succinic acid one hundred and twenty grains, ninety grains of water, and thirty grains of gummy mucilage. 2nd. Dry the paper, and spread over it a solution of nitrate of silver (sixty grains of salt in thirty-seven grains of distilled water). This paper, which may be preserved white, should remain from two to eight minutes in the dark chamber. The impression is developed by a mixture of sixty grains of sulphate of iron and one hundred and twenty to one hundred and eighty grains of gummy mucilage, and is fixed by washing with the ammonia on a solution of hyposulphate of potash.

15. *Kobell's Process.*—1st. Dip the paper into a solution of sea salt (one part of salt

in fifteen of water). 2nd. Dry it, and place it in a flat vessel containing a solution of nitrate of silver. 3rd. Fix the image by means of caustic ammonia, or hypo-sulphate of potash. After fixing the impression, the salt is removed by washing with water.

16. *Martin's Process.—Negative Impression*—1st. Spread over the paper a solution of thirty-six grains of iodine of potassium in one drachm of water. 2d. Dry it in blotting-paper. 3rd. Lay over it a solution of fifty-six grains of azotate of silver in one drachm of water. 4th. Dry it with another clean sheet of blotting-paper. 5th. Repeat all these operations. 6th. Wash it with distilled water with a paint-brush, and dry it in blotting-paper. 7th. Expose it in the dark chamber. 8th. Wash it over with dissolved gallo-nitrate of silver, twenty-seven grains of gallic acid azotate of silver, in one drachm of water. 9th. Wash it with distilled water. 10th. Spread it over twice with a solution of iodine and bromine of potassium, wash it two or three times with distilled water, and dry it thoroughly. *Positive Image*—1st. Cover the paper two or three different times with a solution of nitrate of silver, moisten it with a dabber of cotton wetted through with gallic acid, dry it with care; when the image appears, bring it out with a solution of gallic acid, then dry it. 2nd. Let the paper float on the surface of distilled water for three or four minutes; wash it with a solution of one part of hyposulphate of soda in eight or ten parts of water, then wash it two or three times in distilled water.

17. *O'Shaughnessy's Process.*—Substitute a solution of gold for one of nitrate of silver. The images thus obtained have, it is said, more brilliant tints, with shades of red, purple, and green.

18. *Osann's Process.*—This process consists in the employment of a solution of formate of silver in water. The author prepares this production by means of double decomposition, using sulphate of silver in a concentrated solution of formate of barytes. Fix the image by plunging it several different times in warm water.

19. *Panton's Process.*—Dip the paper in a concentrated solution of bichromate of potash and dry it rapidly by the fire. The image is yellow on an orange ground. If to the bichromate of potash is added sulphate of indigo, various different shades of green will be obtained, and a deepened tone.

20. *Schaffhœult's Process.*—1st. Dissolve two parts and a half of nitrate of silver in six parts of distilled water. 2nd. Pour this solution into a large flat dish, and in it dip one side of the paper. 3rd. Expose this paper, while damp, to the action of the boiling vapours of hydrochloric acid. 4th. Dry it, and in order to render it yet more sensitive, pass it once more upon the solution of nitrate of silver. 5th. Fix the image by plunging the paper for five or ten minutes in alcohol; dry it, and pass it through some diffused hydrochloric acid, in which some drops of pernitrate of mercury have been poured; wash the image with distilled water, and dry it at about 60°.

21. *Schaffhœult's new Process.—Positive Images*—1st. Use paper impregnated with chloride of silver, after the method which has just been shown. 2nd. Let it blacken in the light, and during half an hour keep it plunged in a liquor composed of nine to ten parts of alcohol, and one part of a solution of pernitrate of mercury. 3rd. Pass it quickly over the diffused hydrochloric acid (one part acid and seven to eight parts of water). Wash it rapidly in water, and dry it by a mild heat. This paper is whitened by the rays of the sun, and the images fixed by plunging it in the alcohol, which dissolves the excess of the corrosive sublimate.

22. *Smith's Process* (Tritypic).—1st. Dissolve two grains of carbonate of soda in four grains of water. Filter the solution, and add to it twelve drops of sulphuric or

hydrochloric acid. 3rd. Cover the paper again with this liquor, and dry it in the dark. With this paper is obtained, after twenty minutes to an hour and a half, positive copies of prints. The lights are yellow, the shades violet; by using a double quantity of acid red shades are obtained.

23. *Talbot's Process* (Chloride of Silver Paper).—1st. Choose some thin letter paper, dip it into a weak solution of sea salt, and dry it with a linen rag. 2nd. Spread over one side only, a solution of nitrate of silver (a solution saturated and diffused with six or eight times its weight of water), and dry it slightly.

24. *Talbot's Process* (Bromine of Silver Paper).—Cover some good common paper with a solution of nitrate of silver, then with dissolved bromine of potassium, then again with dissolved nitrate of silver. *Note.* After each operation, care must be taken to dry the paper by the fire.

25. *Talbot's Process* (Calotype).—1st. Prepare the four following liquids:—First liquid, one hundred grains of nitrate of silver dissolved in two hundred and fifty grains of distilled water. Second liquid, five hundred grains of iodine of potassium dissolved in seven thousand grains of distilled water. Third liquid, one hundred grains of nitrate of silver dissolved in two ounces of distilled water; to this solution add a sixth part of its quantity of acetic acid. Fourth liquid, a saturated solution of crystallized gallic acid. 1st. Spread the paper over, one side only, with liquid No. 1, and dry it with care by the fire. 2nd. Dip it in liquid No. 2, and let it remain from two to three minutes; afterwards place it in a glass vessel, and dry it, first between sheets of blotting-paper, afterwards by the fire; keep it in darkness; before making use of it, spread over again a mixture of equal parts of Nos. 3 and 4. Dip it for half an hour in water, dry it, at first, between blotting-paper, then by the fire.

This paper is left only a few minutes in the dark-room, and the image is made visible by spreading over the mixture of liquids indicated (gallo-nitrate of silver). To fix it, the paper is plentifully washed; it is dried between sheets of paper; it is passed with rapidity over one hundred grains of dissolved bromine of potassium in one hundred and forty-eight to three hundred and ten grains (eight to ten ounces) of water; it is once again washed and dried.

26. *Taylor's Process* (a modification of Talbot's method).—1st. Impregnate the paper with a solution of nitrate of silver in ammonia. 2. Fix the images by plunging the paper in boiling water, and leaving it there for two or three days.

27. *Verignon's Process.*—1st. Wash the white paper with water containing a small quantity of hydrochloric acid, and dry it. 2nd. Let it imbibe a solution formed of two parts of sal-ammonia, one part of chloride of strontium, and twenty parts of water; and dry it. 3rd. Dip it into a solution of silver much diffused. 4th. Blacken it by exposing it for half an hour to the action of light. 5th. Let it be impregnated with a very suffused solution of iodine of sodium in the dark, and place it yet wet in the dark-room. The action is finished at the end of twelve minutes. The image is fixed by employing a very diluted solution of hypo-sulphite of silver and iron; after which it is washed in distilled water.

28. *Wood's Process.*—1st. Dip the paper in water, of which three ounces contain two drops of hydrochloric acid. 2nd. Wash it with a mixture of iodine of iron, half a drachm, and one drop of the tincture of iodine in a drachm and a half of water. 3rd. Dry it with blotting-paper, and wash it evenly over with a solution of nitrate of silver (thirty grains of salt in three ounces of water).